

Fall 1985

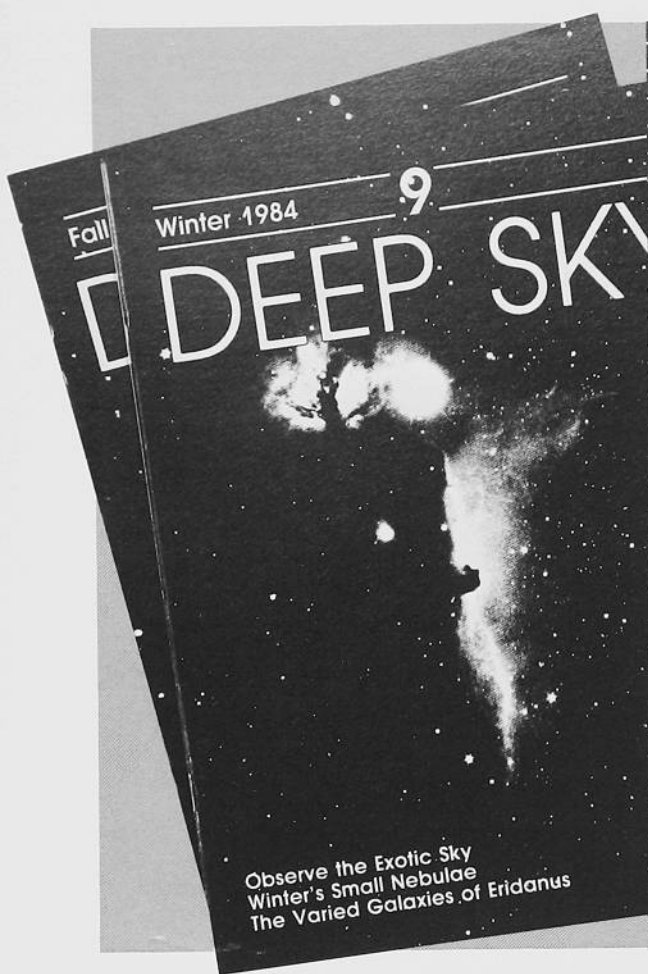
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DEEP SKY



The Deep Sky Wonders of Aquarius
Tilting Spiral Galaxies
Astrophotography: How *Not* To Do It



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Before AstroMedia Corp. — publishers of ASTRONOMY — began publishing DEEP SKY, it existed as a 20-page monthly magazine for deep-sky observers, published by amateur astronomer Dave Eicher in Oxford, Ohio. *DSM* started out as a mimeographed newsletter in June 1977, and by March 1980 became a glossy magazine, complete with observing tips, maps, charts, astrophotos, and articles for observers and photographers in tune with the current state of deep-sky astronomy. The magazine ceased publication with the May 1982 issue, after five years — 60 issues — of production. Now you can buy back issues of *Deep Sky Monthly*, while they last, in a "publisher's closeout" of the *DSM* inventory. The main article in each issue is listed below: other features, illustrations, and articles also appear in each issue. To order, send \$3 for each back issue you mark on the form (or on a copy of the form), and be sure to list second choices if some issues sell out before you get your copy.

DEEP SKY
MONTHLY



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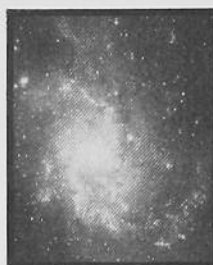


Cover: NGC 7293,
the Helical Nebula in
Aquarius,
photographed by Ron
Potter; 14-inch f/11
SCT, hypersensitized
TP 2415, 180-minute
exposure.

p. 6



p. 14



p. 22



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6 Deep-Sky Wonders of Aquarius

by Jim Barclay, Steve Coe, A.J. Crayon, and Dave Fredericksen

Aquarius the Water Bearer contains a mixed bag of deep-sky objects. It is best known for housing globular clusters M2 and M72 along with the sprawling Helical Nebula. But also inside its boundary are a large number of faint galaxies and other objects, including a 16th magnitude quasar.

16 Astrophotography: How Not To Do It!

by David Healy

Deep-sky photography is a difficult hobby. It requires that you purchase an expensive array of equipment, learn how to use it properly, and eliminate the possibility of any errors interfering with an exposure. In short, successful astrophotography is about as easy as winning the state lottery. Yet backyard astronomers still do it, and many come away with fine photographs. Photography expert David Healy details how to make successful exposures by explaining how not to do astrophotography.

22 Tilting Spiral Galaxies

by Alan Goldstein

Unfortunately we humans suffer from limited perspective in observing other parts of the cosmos. The immense spans of distance between our place in the Milky Way and other galaxies allows us to see only a single "frame" from the ongoing celestial motion picture. When looking at spiral galaxies, however, a darkroom trick can help overcome this limitation: by tilting negatives of inclined galaxies to the correct angle, we can estimate their face-on appearance and gain a better view of their structure. In this article, veteran contributor Alan Goldstein explains his experiments with tilting spiral galaxies.

5 Inside View

Our Perspective on Things

14 Small Scope Showcase

*Of Winking Nebulae and Other
Impossibilities*

20 Deep-Sky Sketchbook

An Album of Galaxies

30 DSM Reports

Taking Note

*The Case of the NGC 6962 Galaxy Group
A Look at S Persei
Photographing Double Stars*

32 Double Stars

Exploring the Struve Catalog

33 Variable Stars

Take a Crack at a Cepheid

36 Scanning the Literature

The Latest Research News

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Inside View

Our Perspective on Things

Rarely when looking up at the sky do we think about how limited our perspective of the cosmos actually is. As deep-sky observers, we're so accustomed to the usual sights that we tend to see the sky as only a two-dimensional shell of stars and galaxies affixed to some sort of backing. But the universe really is a three-dimensional place with vast distances between galaxies which are undergoing constant change. From our observing platform orbiting the Sun — in a spiral arm 11 kiloparsecs away from the Milky Way's center and hundreds of kiloparsecs from the nearest large galaxies — there's not much we can do about changing this perspective!

Yet this issue contains an article which, through a bit of darkroom trickery, does just that. During the last several years, Alan Goldstein — founder of the National Deep Sky Observers' Society — has experimented with tilting photos of galaxies seen at various angles to make them appear face-on. Through this technique, we can approximate what different galaxies look like as viewed from the same angle and glimpse structure not normally visible.

Also in this issue is an article, written by a dedicated group of observers in Arizona and Australia, detailing deep-sky objects found in Aquarius the Water-Bearer. Although best known for the sprawling Helical Nebula, globular clusters M2 and M72, and the Saturn Nebula, Aquarius contains a good deal more — and the crisp, cool nights of

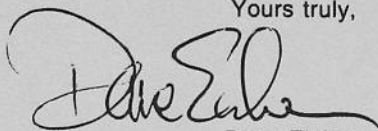
autumn make observing this stuff really relaxing.

In another of his articles about astrophotography, David Healy relates how *not* to do it. How to screw up in astrophotography? It's easy, you say? Well, pay close attention and you'll discover that analyzing mistakes is perhaps the best way to discover the *right* way to take photographs of the sky.

In a slightly expanded "DSM Reports," we feature several unusual and intriguing pieces. The first, written by Brian Skiff, explores the best ways of recording observations. Then Steve Gottlieb, a knowledgeable observer from California, unravels the mystery behind the NGC 6962 galaxy group in Aquarius. Another piece by Skiff recounts his observations of the variable star S Persei, found near the Double Cluster. Finally, Tony Gondola outlines double star photography — a badly neglected field of backyard astronomy.

Your editor is very busy these days, with ASTRONOMY (including a special Halley's Comet issue), *Deep Sky*, various book-writing projects, and an upcoming trip to Lowell Observatory to work as an astronomer — I'll report on my experiences there in an upcoming issue.

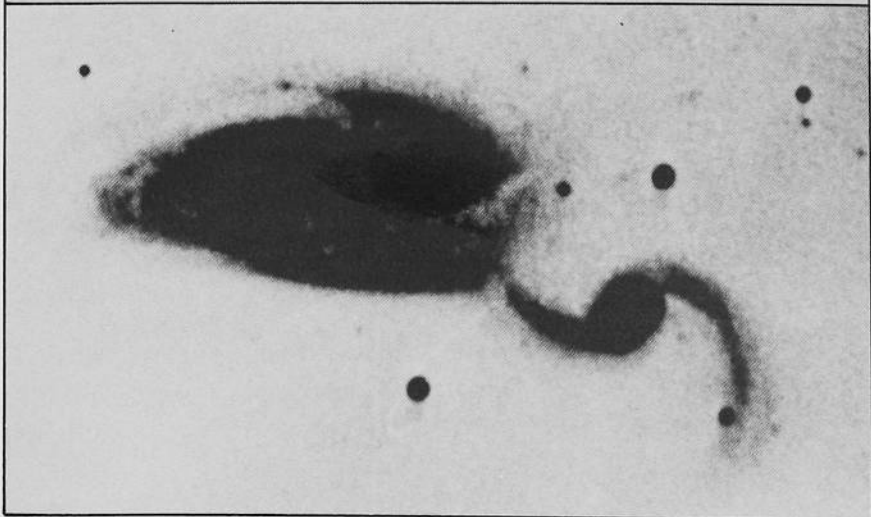
Yours truly,



Dave Eicher
Editor

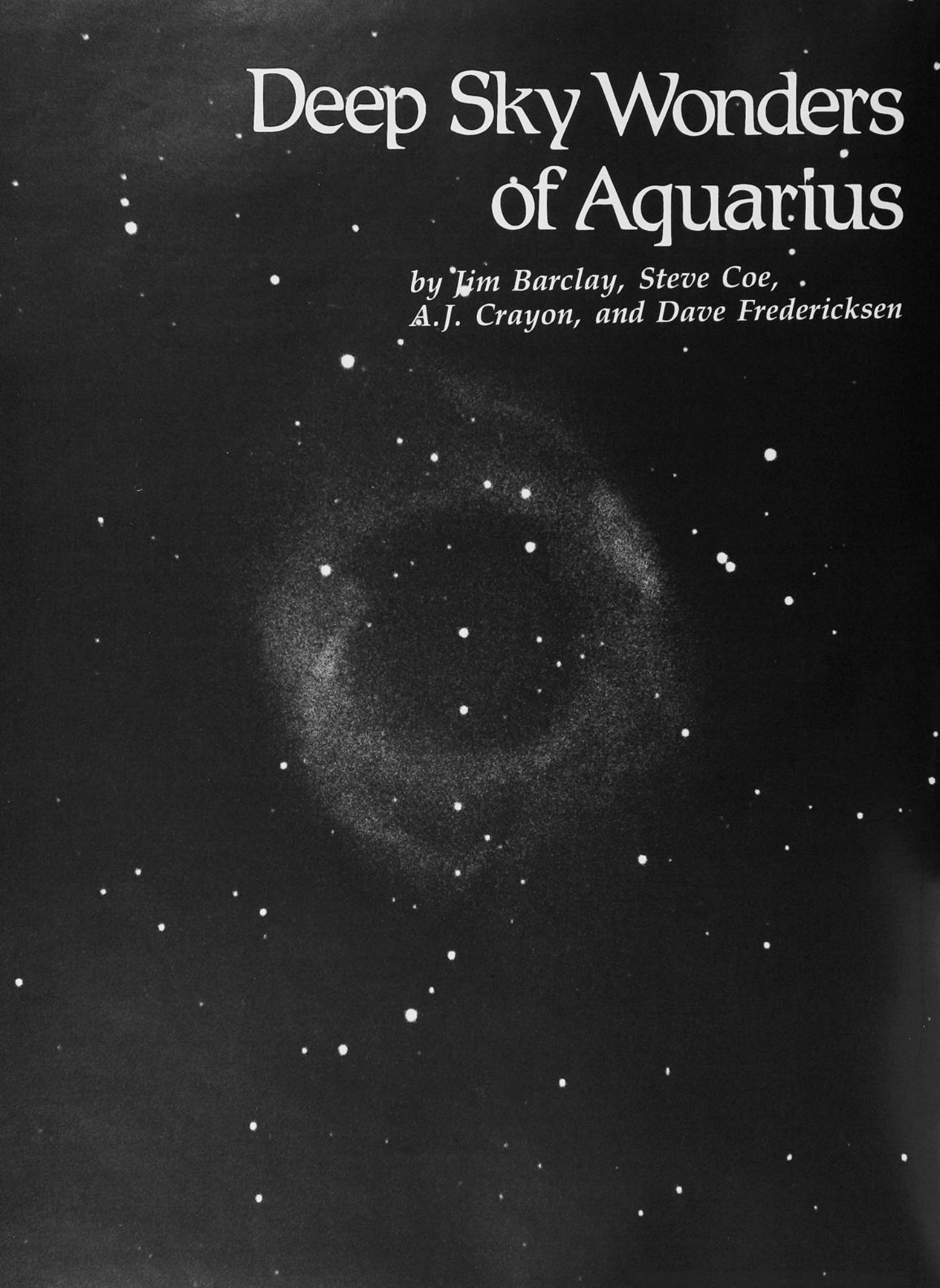
This exquisite shot of the Lagoon and Trifid Nebulae is a 30-minute exposure on hypersensitized 103a-F coupled with a minus violet filter. The telescope was a 12.5-inch f/5 Maksutov, the photographer Jim Riffle, and the result — *par excellence!*

Alan Goldstein



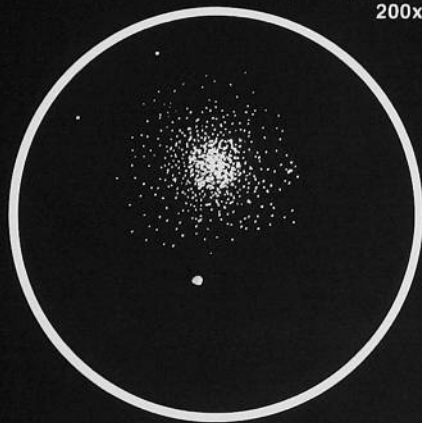
Deep Sky Wonders of Aquarius

*by Jim Barclay, Steve Coe,
A.J. Crayon, and Dave Fredericksen*



Messier 2

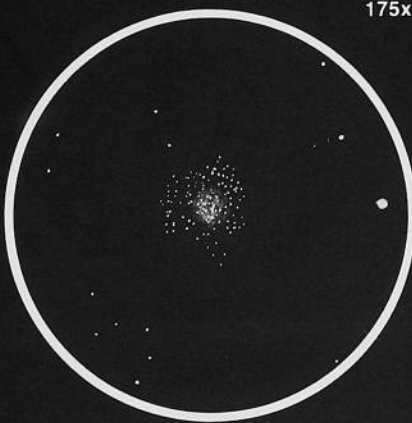
16-inch
f/5 Newtonian
200x



Sketch by Chris Schur

Messier 72

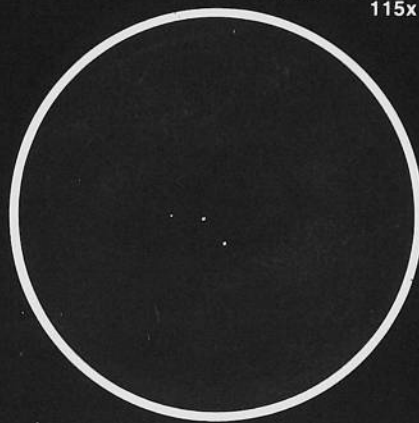
17.5-inch
f/4.5 Newtonian
175x



Sketch by Steve Coe

NGC 7293

8-inch
f/6 Newtonian
115x



Sketch by A.J. Crayon

Throughout most of recorded history, the constellation Aquarius has been associated with water in one way or another. Ancient Babylonian art depicts a boy pouring water from an urn at this place in the sky. Arabian astronomers saw an amphora, a two-handed water jar, at this spot. Even the ancient Chinese called this constellation the Turtle, a creature that frequents wet and marshy regions. One idea has the Egyptians starting it all, noticing that the Nile rose when the Sun entered Aquarius. That would have happened some 150 centuries ago!

Regardless of how it began, Aquarius the Water-Bearer is bounded by Pisces the Fish and Capricornus the Sea-Goat, and nearby are Eridanus the River and

Cetus the Whale. Talk about a watered-down situation! Fortunately all of the deep-sky goodies aren't "washed-out" of Aquarius, and there is still plenty to look at. Although principally known for the two bright globular clusters M2 and M72 and the planetary nebulae NGC 7009 and NGC 7293, Aquarius contains a varied selection of other splendors, including many little-observed galaxies.

Probably the finest object in Aquarius is the bright globular cluster **Messier 2** (NGC 7089). This is a large cluster, spanning some 12.9' across, making it easily visible in binoculars or finder telescopes as a small, fuzzy circular patch. It shines at magnitude 6.5, placing it just beyond naked-eye range from a dark location. It lies roughly 15° due south of the globular M15 in

Left: The Helical Nebula, NGC 7293, is the largest, brightest, and nearest planetary nebula — yet it is notoriously difficult to observe because of low surface brightness. Photo by Martin C. Germano; 8-inch f/10 SCT, 90-minute exposure on 103a-F film. **Above:** The globular cluster M72 is bright and easy to observe with nearly any telescope. Photo by Martin C. Germano; 8-inch f/10 SCT, 25-minute exposure on 103a-F film.

Messier 73

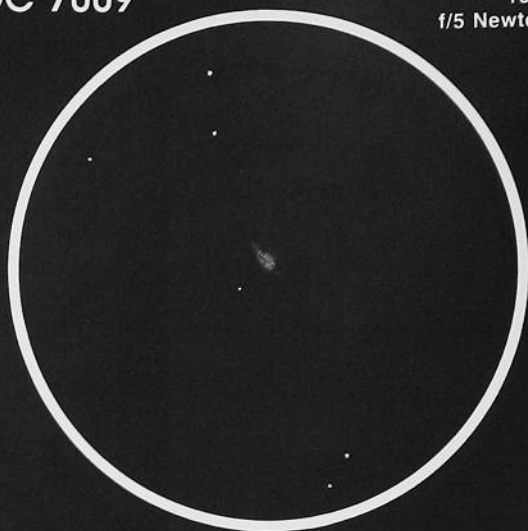
8-inch
f/6 Newtonian
100x



Sketch by A.J. Crayon

NGC 7009

16-inch
f/5 Newtonian
200x



Sketch by Chris Schur

NGC 7371

16-inch
f/5 Newtonian
144x



Sketch by Chris Schur

NGC 7585

17.5-inch
f/4.5 Newtonian
100x



Sketch by Steve Coe

Pegasus, making finding it relatively easy.

An 8-inch scope under a clear Arizona sky resolves about 100 stars across the face of M2, making it a commanding sight — although a hazy, unresolved background remains. A 12.5-inch resolves noticeably more stars, particularly in the core area. A 17.5-inch telescope at 165x brings out an overwhelming number of stars; several hundred in the outer halo of the cluster, many being arranged in lovely chains. The 17.5-inch resolves about 30 stars in the cluster's center, seemingly suspended in front of a milky background. The large reflector transforms M2 from a typical unexciting cluster to a bright, magnificent sight.

Aquarius' second Messier globular cluster is **M72** (NGC 6981), which lies

in the southwestern corner of the constellation, due north of Capricornus. M72 is only half as large as M2, and consequently appears less enthralling. It is nevertheless still bright, at magnitude 9.4, and appears like a typical elliptical galaxy in small telescopes. Using an 8-inch telescope at 100x from Arizona, the cluster appeared resolved — to the extent of 12 stars — about its edges. The 17.5-inch reflector at 165x showed about 50 stars standing out over a hazy disk, including one or two inside the cluster's core. From Australia, where the cluster passes virtually overhead, a 12.5-inch telescope at 120x resolved the cluster quite clearly, with several chains of stars extending outward from the nucleus. This is startling testimony for observing objects near the meridian when

possible.

Lying just 2° due east of M72 is the infamous star cluster **M73** (NGC 6994). One of the worst Messier objects, along with double star M40 in Ursa Major and the poor cluster M29 in Cygnus, M73 is simply a group of four faint stars. The combined photographic magnitude for this cluster is 8.9, while the brightest star shines at 10th magnitude. The long axis of the group is 2.8', and there is no nebulosity involved. After viewing M73 you'll probably think it is one of the most ridiculous deep-sky objects you've ever observed. It may or may not be a physical cluster of stars. Even if it is, it's a pretty poor example.

Much more exciting is the renowned planetary nebula **NGC 7009**, located 3° northeast and some 2° due west of the bright star Nu (ν) Aquarii. Discovered as

NGC 7184

12.5-inch
f/6 Newtonian
108x



Sketch by Dave Fredericksen

NGC 7300

17.5-inch
f/4.5 Newtonian
100x



Sketch by Steve Coe

NGC 7600

16-inch
f/5 Newtonian
90x



Sketch by Chris Schur

NGC 7606

8-inch
f/6 Newtonian
80x



Sketch by A.J. Crayon

a bright nonstellar disk in 1782 by William Herschel, later NGC 7009 received a famous nickname from the Third Earl of Rosse, William Parsons. With his 72-inch reflector at Birr Castle he observed two faint, thin ansae protruding from each end of the nebula, and called it the "Saturn Nebula." Other backyard astronomers have been trying to duplicate that observation ever since.

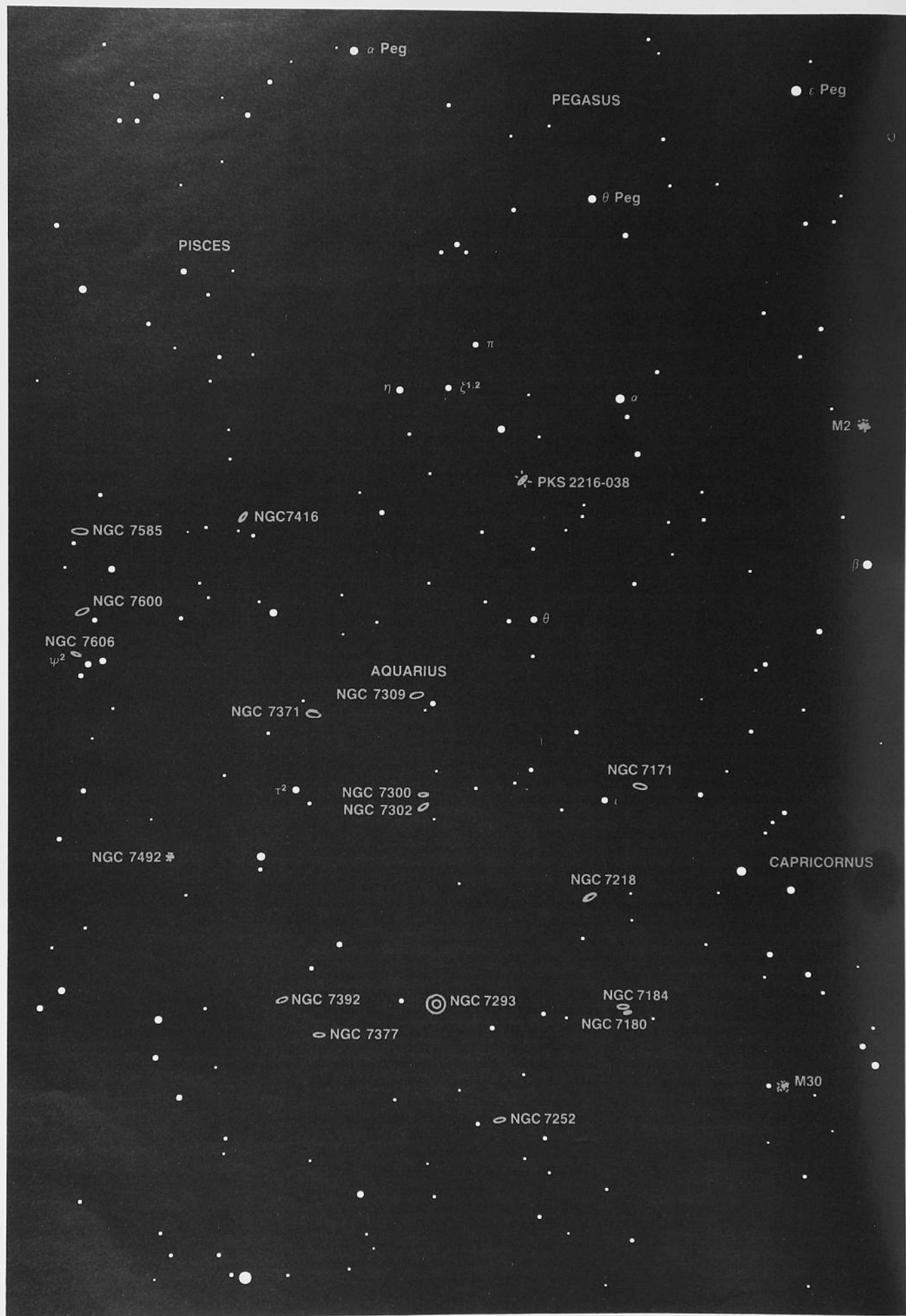
An 8-inch telescope at 115x shows the Saturn Nebula as a bright, greenish, slightly elongated disk. Both 12.5-inch telescopes — one in Arizona, the other in Australia — clearly show the elongation and a more pronounced bluish or bluish-green color. In Arizona 16-inch and 17.5-inch telescopes show the delicate ansae, but only with averted vision on an exceptionally dark and transparent night. The nebulosity

appears greenish, and no central star is visible. Operating at 250x, Richard and Helen Lines' 20-inch f/6 reflector shows the Saturn Nebula beautifully, including a tiny bulge in one of the ansae. During moments of steady seeing the central star — shining at 11th magnitude but deeply embedded in nebulosity — was visible. After one night's observing we paused to reflect: the subtle light we saw from NGC 7009 and its features traveled over 3,000 years to arrive on our retinas.

Since it lies east of Aquila and well away from the plane of the Milky Way, Aquarius contains innumerable small galaxies. NGC 6962 is the brightest of a small group of three galaxies in the northwestern corner of Aquarius. A 12th magnitude barred spiral, NGC 6962 measures 3.0' x 2.5' and has an

average surface brightness of 14.9 magnitudes per arcminute. It is visible in a 10-inch scope as a fuzzy patch, but this galaxy is not an easy target for smaller scopes. Nearby NGC 6963, a 14th magnitude probable elliptical galaxy, measures only 0.7' x 0.7'. Hence its surface brightness is a little higher than NGC 6962's, and it may be easier to spot. NGC 6964, a magnitude 12.7 elliptical with peculiarities, measures 1.9' x 1.4' and is about as difficult to observe as neighbor NGC 6962.

Moving eastward, we find the barred spiral NGC 7171 lying 2.5° northwest of Iota (i) Aquarii, just south of the ecliptic. This galaxy shines at magnitude 12.3 and measures 2.8' x 1.7', giving it an average surface brightness of 14.5. From Australia, a 12.5-inch scope



Deep Sky Objects in Aquarius

Type	Designation	R.A. (2000)	Dec.	Mag.	Mag.*	B-V	SB	Size	N*	Sp. Type	Period	Dist.
SAB(r)ab	NGC 6962	20h47.3m	+00°19'	12.0	—	0.9	14.9	3.0' x 2.5'	—	—	—	60 Mpc.
E1:	NGC 6963	20h47.3m	+00°29'	14.1	—	0.9	14.3	0.7' x 0.7'	—	—	—	60 Mpc
E4pec:	NGC 6964	20h47.4m	+00°18'	12.7	—	1.0	14.8	1.9' x 1.4'	—	—	—	55 Mpc
●	M72 (NGC 6981)	20h53.5m	-12°32'	9.4	—	0.7	—	5.9'	—	G0	—	17.3 kpc
○	M73 (NGC 6994)	20h59.0m	-12°38'	8.9p	10p	—	—	2.8'	4	—	—	—
■	NGC 7009	21h04.2m	-11°22'	8.3p	11.3	—	—	25"	—	Cont.	—	0.9 kpc
●	M2 (NGC 7089)	21h33.5m	-00°49'	6.5	—	—	—	12.9'	—	F3	—	11.3 kpc
SB(rs)b	NGC 7171	22h01.0m	-13°16'	12.3	—	0.7	14.5	2.8' x 1.7'	—	—	—	35 Mpc
S ?	NGC 7180	22h02.3m	-20°33'	12.5	—	0.9	13.8	1.8' x 0.9'	—	—	—	20 Mpc
SB(r)c	NGC 7184	22h02.7m	-20°49'	12.0B	—	—	14.1	5.8' x 1.8'	—	—	—	35 Mpc
SB(rs)cd	NGC 7218	22h10.2m	-16°40'	12.1	—	0.5	13.7	2.5' x 1.3'	—	—	—	24 Mpc
QSO	PKS 2216-038	22h18.8m	-03°36'	16.4v	—	0.6	—	stellar	—	—	—	—
(R)SA(r) :	NGC 7252	22h20.7m	-24°41'	12.1	—	0.6	14.1	2.2' x 1.8'	—	—	—	65 Mpc
■	NGC 7293	22h29.6m	-20°48'	6.5	13.5	—	—	769"	—	—	—	0.1 kpc
SAB(rs)b:	NGC 7300	22h31.0m	-14°00'	12.9	—	0.8	14.6	2.2' x 1.2'	—	—	—	55 Mpc
SA(s)~:	NGC 7302	22h32.4m	-14°07'	12.1	—	1.1	14.1	1.9' x 1.3'	—	—	—	35 Mpc
SAB(rs)c	NGC 7309	22h34.3m	-10°21'	12.5	—	0.5	14.5	2.1' x 2.0'	—	—	—	55 Mpc
(R)SA(r) :	NGC 7371	22h46.1m	-11°00'	12.1	—	0.7	14.2	2.1' x 2.0'	—	—	—	35 Mpc
SA(s) +	NGC 7377	22h47.8m	-22°19'	11.6	—	1.0	14.0	2.2' x 1.8'	—	—	—	45 Mpc
SA(s)bc	NGC 7392	22h51.8m	-20°36'	11.9	—	0.8	13.5	2.0' x 1.3'	—	—	—	40 Mpc
SB(r)b	NGC 7416	22h55.7m	-05°30'	12.3	—	0.8	14.4	3.4' x 1.2'	—	—	—	40 Mpc
●	NGC 7492	23h08.4m	-15°37'	11.5	—	0.5	—	6.2'	—	—	—	21.9 kpc
(R)SA(S) pec	NGC 7585	23h18.0m	-04°39'	11.7	—	0.9	14.1	2.3' x 1.9'	—	—	—	45 Mpc
S~spindle	NGC 7600	23h18.9m	-07°35'	13.0B	—	—	13.8	2.4' x 1.1'	—	—	—	50 Mpc
SA(s)b	NGC 7606	23h19.1m	-08°29'	10.8	—	0.8	14.3	5.8' x 2.6'	—	—	—	30 Mpc
SA(s)c	NGC 7721	23h38.8m	-06°31'	11.8	—	1.1	13.9	3.4' x 1.5'	—	—	—	30 Mpc
SB(r)b	NGC 7723	23h38.9m	-12°58'	11.1	—	0.7	14.1	3.6' x 2.6'	—	—	—	25 Mpc
SAB(s)a pec	NGC 7727	23h39.9m	-12°18'	10.7	—	0.9	14.3	4.2' x 3.4'	—	—	—	25 Mpc
SV	R	23h43.8m	-15°27'	5.9→11.4	—	—	—	—	—	gM7ep	386d	250 pc

shows it as being faint and nebulous with a hint of mottling. Increasing the power to 190x shows a stellar core with averted vision. The 17.5-inch scope doesn't do much better.

Some 7° south of NGC 7171 are two more galaxies, **NGC 7180** and **NGC 7184**. NGC 7180 is a 12.5 magnitude spiral measuring 1.8' x 0.9'; it has a fairly high surface brightness of 13.8. Just southeast in the same field, NGC 7184 is a big barred spiral spanning 5.8' x 1.8', and shining at magnitude 12.0. An 8-inch scope shows this galaxy as nothing more than a dim patch. A 12.5-inch in Arizona shows a bright, condensed core with very faint nebulosity surrounding it; structurally it was almost reminiscent of NGC 253 in Sculptor. The 17.5-inch telescope showed a dark lane as well as better definition across the galaxy's face.

NGC 7218 is a 12th magnitude barred spiral lodged between the bright double stars 29 and 53 Aquarii. Measuring 2.5' x 1.3' in extent, this galaxy has a surface brightness of 13.7 and is therefore difficult to spot in small telescopes. It appears as a fuzzy oval patch with a bright center in moderate size scopes, but doesn't reveal much detail. With the 17.5-inch at 135x, the elongation appeared quite obvious and the nucleus appeared bright.

Several degrees southwest of the bright, Y-shaped asterism named the "Water Jar" is a faint but curious object — the quasar **PKS 2216-038**. Although it is normally at about 16th magnitude, this QSO is within the sights of the largest backyard telescopes and is

easily photographed used amateur instruments.

The galaxy **NGC 7252** lies near the southern border of Aquarius, about 1.5° west of 49 Aquarii. This object is classified as a strange spiral, but this interpretation is uncertain. It measures 2.2' x 1.8' across and shines at 12th magnitude, giving it an overall surface brightness of 14.1. Due to its southern declination, it is rather difficult from the United States; from Arizona the 17.5-inch scope barely distinguished it from the surrounding field stars. From Australia, the 12.5-inch scope at 190x bettered that by revealing a stellar nucleus.

A degree northeast of the star 56 Aquarii are the faint galaxies **NGC 7300** and **NGC 7302**. NGC 7300 is a barred spiral of 13th magnitude, covering some 2.2' x 1.2' of sky. Its surface brightness is 14.6. NGC 7302 is brighter, at magnitude 12.1, and about the same size — its surface brightness is 14.1. Both appear roughly the same at the eyepiece, being faint in the 17.5-inch scope at 100x. Each has a bright nucleus and is compact as a whole. NGC 7300 is somewhat elongated, while NGC 7302 appears rounder. Together they comfortably fit inside a 30' diameter field of view.

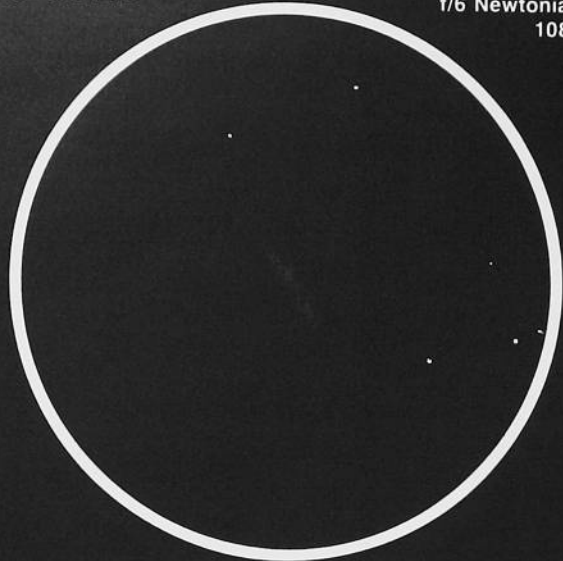
A little over 4° north of the 7300/7302 pair, forming an isosceles triangle with the bright stars Sigma (σ) and 58 Aquarii, is the galaxy **NGC 7309**. At magnitude 12.5 and with a surface brightness of 14.5, this galaxy is very faint. The 17.5-inch scope working at 135x showed NGC 7309 as being round



NGC 7606, an 11th magnitude spiral, is the brightest galaxy in Aquarius. It measures 5.8' x 2.6' and features a bright nucleus surrounded by diffuse arms. Photo by Jim Barclay; 12.5-inch f/6 Newtonian, 60-minute exposure on 103a-O film.

NGC 7721

12.5-inch
f/6 Newtonian
108x



NGC 7723

12.5-inch
f/6 Newtonian
108x



Sketches by Dave Fredericksen



NGC 7009, popularly known as the Saturn Nebula, is visible in any telescope as a bright disk. It takes a large scope and high power, however, to have even a chance of spotting the tenuous ansae which give NGC 7009 its nickname. Photo by Dan Marcus and Bill Smith; 12.5-inch f/5.2 Newtonian, 40-minute exposure on hypersensitized TP 2415.

with a bright middle; averted vision brought out the arms as a faint haze.

Slightly brighter is the spiral **NGC 7371**, which lies just north of an 8th magnitude star, on a line drawn from Delta (δ) through Tau² (τ^2) Aquarii and continued for an equal distance. The 12th magnitude galaxy is nearly circular, measuring 2.1' x 2.0' across, and glows at 12th magnitude. The 17.5-inch scope shows a bright nucleus surrounded by a faint glow — the unresolved spiral arms. The galaxy appears round and small at 135x.

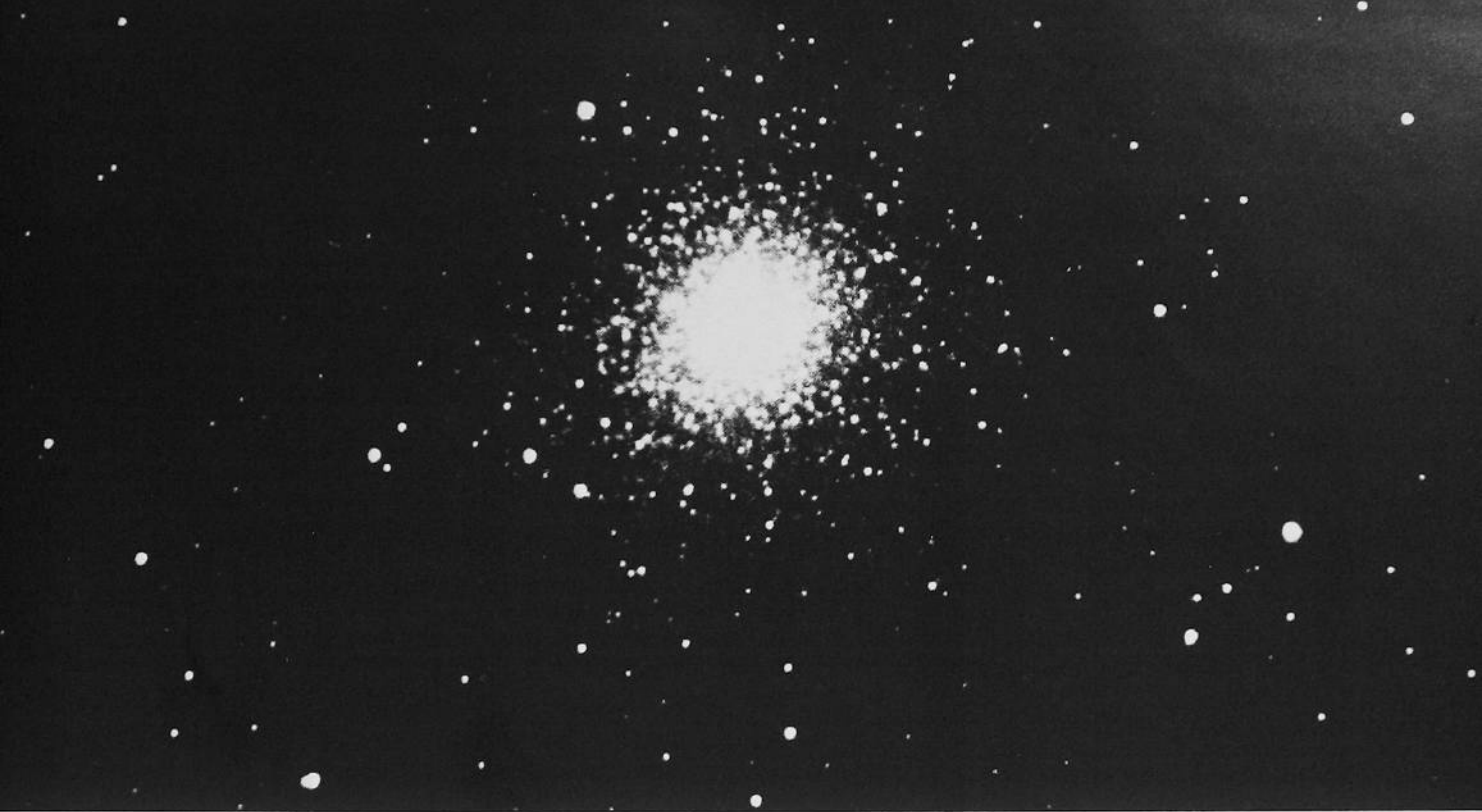
Two relatively bright galaxies lie in the south-central part of the constellation — **NGC 7377** and **NGC 7392**. NGC 7377 is a spiral measuring 2.2' x 1.8' and glowing at magnitude 11.6; its surface brightness is 14.0. From Australia, the 12.5-inch scope revealed a stellar nucleus and — with averted vision — some mottling in the galaxy's halo. From Arizona, the 17.5-inch scope didn't do nearly as well. NGC 7392, also a spiral, measures 2.0' x 1.3' and shines at magnitude 11.9. Because it is smaller than NGC 7377, its surface brightness is considerably higher. The 17.5-inch scope showed NGC 7392 as a pretty faint, elongated patch of light. To see these two objects well at all from the United States, you'll need a clear southern horizon and an exceptionally dark night.

Large but rather faint, the spiral **NGC 7416** is isolated from other notable galaxies. It spans 3.4' x 1.2', glows at magnitude 12.3, and has an average surface brightness of 14.4. Large scopes generally show this galaxy as a

large faint fuzz with a slightly condensed core.

Three fine galaxies are arranged in a north-south line nearly five degrees long beginning just above the bright triplet of stars Psi¹, Psi², and Psi³ Aquarii. The southernmost galaxy is **NGC 7606**, a magnitude 10.8 spiral measuring 5.8' x 2.6' in extent. This object is not edge-on but highly-inclined, and appears in an 8-inch scope as a large, elongated patch of fuzz. The 12.5-inch scope in Arizona reveals a bright, condensed nucleus. About 1.5° north of NGC 7606 is **NGC 7600**, a faint galaxy covering only 2.4' x 1.1'. With a blue magnitude of 13, not much of this object is visible: the 17.5-inch scope shows it as a small, faint blur at 135x. About 3° north of NGC 7600 is the third galaxy in the string, **NGC 7585**. This object is a bright roundish spiral with peculiarities; it measures 2.3' x 1.9' and shines at magnitude 11.7. From Arizona a 16-inch scope showed a bright nucleus and, with averted vision, faint haze surrounding it. The 17.5-inch showed the nucleus as being stellar, and at 100x revealed two small companion galaxies in the field. A low-power view includes 96 Aquarii, a bright, blue and white double star.

The final three galaxies lie in the northeastern part of Aquarius. Approximately 8° due east of Phi (ϕ) Aquarii is **NGC 7721**, a bright spiral. This galaxy shines at magnitude 11.8 and covers 3.4' x 1.5' of sky, giving it an average surface brightness of 13.9. In an 8-inch scope it appears faint at 80x. Surprisingly, the 17.5-inch scope



doesn't help the view much — it still appears as a faint, elongated patch of light. Roughly 8° south of NGC 7721, the galaxies **NGC 7723** and **NGC 7727** lie within 1.5° of each other. NGC 7723 is similar to NGC 7721: it is slightly brighter but also slightly larger, so that its surface brightness is roughly the same. At 190x, a 12.5-inch scope in Australia shows a mottled, elongated surface. In Arizona, the 17.5-inch scope just matches that observation. At magnitude 10.7, NGC 7727 is the brightest galaxy in Aquarius. It is large, however — $4.2' \times 3.4'$ — and therefore its spiral arms appear faint. The 8-inch telescope reveals a roundish glow with a bright middle, encircled by a chain of faint stars in the field. The 17.5-inch scope at 100x shows a highly condensed nucleus and a companion galaxy about $20'$ away.

One of the most curious objects in the constellation is the globular cluster **NGC 7492**. About the same size as M72 but two magnitudes fainter, this subtle ball of faint stars is a challenge to owners of small telescopes. To find NGC 7492, place Delta (δ) Aquarii in the field of a wide-angle eyepiece in a polar-aligned scope, and wait 13 minutes and 40 seconds. The cluster will drift right into view. This is a difficult object: the 12.5-inch scope revealed only a faint glow, and the 17.5-inch scope didn't help much. Don't be discouraged if this one taxes all of your observing skill.

Perhaps the most unusual object in Aquarius is the complex nebulosity centered on the variable star **R Aquarii**. This star varies between magnitudes

5.9 and 11.4 over a period of 386 days, and is one of the mysterious so-called symbiotic stars (see *Deep Sky* #11). The star has expelled a shell of nebulosity of extremely low surface brightness. Can anyone detect nebulosity surrounding this bizarre star?

Our grand finale is the largest, brightest, and closest planetary nebula in the sky — **NGC 7293**, the Helical Nebula. Having read statements like the last sentence, many observers rush out to see the brightest, biggest planetary only to find absolutely nothing at its position. The Helix is one of the grand examples of low surface brightness: its total magnitude is 6.5, yet this light is spread over an area roughly $15' \times 12'$ across, making small individual parts of it very dim. The best approach with the Helix is to wait for a very dark sky and search for it with a pair of binoculars or a wide-field telescope. Ample surrounding sky helps, as it keeps the contrast between nebula and sky fairly high. Under a black sky, the Helix is visible with a 50mm aperture as a nebulous spot $\frac{1}{4}^\circ$ across. With small telescopes no structure is visible beyond detecting the central "hole" in the nebulosity. Larger scopes, however, show the nebulosity slightly brighter here and there, and yield a very satisfying view.

Although it isn't among the best-stocked constellations for deep-sky observers, Aquarius contains a unique blend of curious Milky Way objects and numerous galaxies on which to test your abilities. This fall scan through Aquarius — you'll be pleased at the objects you probably were unaware of up until now.

M2 is the finest globular cluster in Aquarius, although it is often unjustly overshadowed by nearby **M15** in Pegasus. Photo by Martin C. Germano; 8-inch f/10 SCT, 35-minute exposure on 103a-F film.

*"After viewing M73
you'll probably think
it is one of the most
ridiculous deep-sky
objects you've ever
observed!"*

Jim Barclay is an energetic observer and astrophotographer from Queensland, Australia. Steve Coe, A.J. Crayon, and Dave Fredericksen are members of the Saguaro Astronomy Club near Phoenix, Arizona. All are experienced observers and frequent contributors to Deep Sky.

Small Scope Showcase

Of Winking Nebulae and Other Impossibilities

by David H. Levy

"Have you ever seen the winking nebula?"

This sounded like the opening line of a bad joke, especially coming from an expert observer like Leo Enright. How could a nebula a light-year across wink?

And it was a Friday night, at a star party following an astronomy club meeting — and you know the mood people get into after all that old business and new business. They'll say anything.

So, cynical soul that I am, I just grinned at him. "I don't believe a word you're saying."

"No, really," Leo went on. "It's true."

We both looked up at the clear, dark sky over Sharbot Lake, Ontario. I mean, one of us was supposed to be a phenomenal observer, but I was beginning to wonder about ol' friend Leo!

"NGC 6826," he insisted. "It's just five degrees north of Delta Cyg."

By then a cloud (an unwelcome but frequent visitor that takes the "star" out of the club parties) had rolled in and we had to stop observing for a while. Leo said little more about the nebula. When the sky finally cleared again, we spent our time enjoying favorite deep-sky objects like M31 — the Double Double in Lyra — all the fun things that make the sky so interesting.

But then Leo wouldn't leave it alone. "In the wink of an eye," he said sagely, "you can make a whole nebula disappear."

Carefully, deliberately, and with a look that was positively Ulyssean — you recall, of course, that Homer's hero has a name meaning "cagy" or "crafty" — Leo slo-o-o-wly zero'd in his telescope on the mysterious object in Cygnus. Then he stopped, peered through the eyepiece for what seemed like an hour but was probably just a few minutes, and said, "There. Now you try, David."

I looked in.

Lo and behold, it *did* wink! It really did!

And here I'd been thinking only people could do that — you know, like when they infer that "you and I have a secret." Stars are people, too!

After a while, my expert friend and I figured out there must be lots of objects like this — because, of course, stars really don't "wink." A stellar wink is a subjective thing created in the eye and mind of an observer.

With planetary nebulae, this optical illusion occurs when the central star is approximately the same brightness as the surrounding nebulosity. As you concentrate on the star, the nebulosity seems to disappear. It promptly comes back again as you shift your attention away from the star. But stellar winking is a personal thing, and what winks for me may not wink for thee. It depends partly on what size telescope you use, and even more on the size of the field of view. For NGC 6826, I prefer Schmidt-Cassegrains (with their narrower fields) to the wide expanses of a Newtonian field, because the nebular light appears less concentrated, hence fainter and closer in brightness to that of the star.

You can try this with other planetary nebulae, too — like M57, the Ring Nebula in Lyra. We discussed this



NGC 6826, a bright planetary nebula in Cygnus: *winking*.

object in the last issue, but not from the point of view of the central star since you probably won't see it unless you have a 16-inch telescope under the darkest of dark skies. Give some non-planetary nebulae a try also, and see if this happens to the region of nebulosity immediately around the stars embedded within them.

There's a serious point I am trying to make here. The sky is personal. Depending on what you are looking for, you may well see it. Now this may be good fun, but it's hardly scientific. One of the hallmarks of a skilled observer, like my friend Leo, is that you always know and distinguish between what is real and what's an artifact of your own brain. Once you learn to make the distinction habitually, your abilities as a

serious observer increase rapidly.

This notion is hardly new. Writing about the abilities of seeing that led to his discovery of Uranus, William Herschel (one of the greatest observers who ever lived) opined, "Seeing is in some respects an art which must be learnt. To make a person see with such a power is nearly the same as if I were asked to make him play one of Handel's fugues upon the organ. Many a night have I been practicing to see, and it would be strange if one did not acquire a certain dexterity by such constant practice."

So this season, try looking at a number of planetaries and see if they wink at you. They may be trying to tell you that you're becoming a better observer.

The autumn sky boasts a number of good planetaries to look at, specifically:

1. The Ring Nebula, **M57**, is by far the most famous planetary in the entire sky and very easy to find (it's on chart 8 in Tirion's *Sky Atlas 2000.0*).

2. The Dumbbell Nebula, **M27** in Vulpecula, is an interesting specimen of a large planetary with a central star that you may see with an 8-inch or larger telescope (charts 8 and 9).

3. The Little Dumbbell, or **M76**, looks like a misty spot through a small telescope; a larger scope at higher power turns it into a miniature M27. Don't let the "official" magnitude of 12.6 deceive you; this is a relatively easy object (charts 1 and 4).

4. The Saturn Nebula, **NGC 7009**, in Aquarius lies about 1.5° west of Nu (ν) Aquarii. Use high power and see if it looks a bit like a poorly-focused image of the ringed planet (chart 16).

5. The Helical Nebula, **NGC 7293**, also in Aquarius, is very large. Its apparent diameter is theoretically half that of the Full Moon, although you need a dark sky, low magnification, and a good telescope to see that much of it (chart 23).

6. If you stay up late, or if you keep all your issues of *Deep Sky* (of course you do!) and are reading this article in winter, try the open cluster M46 in Puppis. Within its starry borders lies **NGC 2438**, a beautiful planetary. Its cluster and nebula provide a very striking sight (chart 12).

How do all these planetaries differ visually from other deep-sky objects? For the most part, they seem to be condensed enough and have high enough surface brightnesses that you can see them from suburban locations. Most of the planetaries listed here are easy to spot in small telescopes.

Jack B. Newton



Jay Anderson

Globular cluster M15 in Pegasus: a bright, easy-to-observe glistening ball of half a million suns.



Lee C. Coombs

Spiral Galaxy M33 in Triangulum: low-contrast, but a chance to observe rich galactic detail.

Of course, planetaries are not all there is to see in the crystalline skies of fall. I encourage you to look at two nice globular star clusters, M15 and M2 (both on Tirion chart 17). **M15** in Pegasus is my favorite object — not because it is the best globular (M13, discussed in *Deep Sky* 11, is far more spectacular), but because it is the object I was assigned to show the public at my first big star night years ago. Ever since, I have felt a special joy whenever I look at it.

On the other hand, **M2** is my *least* favorite object — but not because it isn't worth looking at (it most certainly is). You see, one night I spent an hour — *60 minutes*, mind you — exposing film on this object. The photo showed it had a tail. But M2 isn't a comet, and it shouldn't have a tail! I learned a lot that night about guiding a telescope so that the object doesn't move around during the exposure — but still, M2 should know better.

This is also a time for galaxies, particularly the second most famous of them all — the Andromeda Galaxy, **M31** (chart 4). You don't need a big telescope, you don't need a country sky, you hardly even need any brains to enjoy this magnificent spiral system. With a small telescope, you can easily see that it is an oblong blob of light; no matter how much more light-gathering power and magnification you give, you still won't see all the little stars contained therein. But as the sky gets better and you use greater aperture, the misty spot gets clearer and more structured, and essentially more magnificent.

This huge spiral galaxy was once thought to be much bigger than its soul

mate and neighbor, our own Milky Way. And new research does indicate that M31 is bigger, but not by much. If you live under a dark sky and find M31 a bit too easy, try **M33** — a face-on spiral in neighboring Triangulum (chart 4).

Face-on? Yes, we do see different galaxies at different aspects. M31 is essentially a dinner plate tilted somewhat toward our line of sight; M33 is another dinner plate presented more-or-less face-on. It's also a smaller system and farther away — hence it is fainter. Moreover, it spreads out and is thus a rather diffuse object. Many observers find M33 difficult or impossible to detect against a bright sky background. You'll need a wide field of view and good sky contrast to see it, so if you're observing from a city or the suburbs and can't find M33, plan on a trip farther out next time.

Face-on — tilted — are there any galaxies in the fall sky that are edge-on toward us? Actually, there are none in the northern sky that can be found easily, but the southern constellation of Sculptor contains a real beauty: **NGC 253**, a large edge-on spiral galaxy (chart 18).

For one last object, let's move to Taurus and back into our own Galaxy. Take a look in the northeast, just where Cassiopeia meets Perseus. Here is one of the most magnificent open star clusters in the entire heavens, a wondrous conglomeration of stars known as the **Double Cluster** (chart 1). The best way to look at this cluster is with a wide-field telescope which increases the contrast between the stars and the dark sky background. The Double Cluster works from any location, even a city, because it is a cluster of

pinpoint stars — not a fuzzy nebulosity whose subtle glow can be swamped by light pollution.

* * *

In a sense, deep-sky observing is like collecting stuff. Some people collect stamps, others parking tickets. What I hope you will start to do with your telescope is collect deep-sky objects. Each of the planetary nebulae, clusters, and galaxies you see with your telescope gets added to your "life list" of objects.

Almost all the objects we discuss in this column have "M" (for Messier) numbers. Some astronomy groups sponsor a friendly competition to encourage their members to observe all these objects. The Astronomical League, in fact, has an award that you can get when you see over 75 of them, and a second award when you see the entire list of some 107 objects. The theoretical total is 109, but comet hunter Charles Messier confused the positions and garbled the identifications for two. Thus we have M40, which is actually two faint stars, and M91, which is an accidental repetition of M58.

Behind the competition lies a more serious purpose — these objects offer some of the finest examples of deep-sky objects in the entire heavens. And Messier left his mark everywhere — these objects are spread all over the sky. I can give a sampling here, but you can find many more using other articles in *Deep Sky*.

Why sit around and wait? These objects are going to last for only tens of billions of years — so hurry!

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Tucson, AZ 85747

How *NOT* To Do It, or, The 35mm as Teabag, Shooting M40, and More

By David Healy

There is a definite hierarchy, a distinct pecking order in deep-sky photo mistakes. Years of striving have made me an advanced messer-up of astronomical photos, and I believe that I have recently broken new ground. Technologically speaking, the high point of a recent astrophoto excursion of mine was the submersion of my Miranda Laborec 35mm camera (and its load of hypersensitized Technical Pan 2415 film) in a bath of ice water for several hours. In the absence of refrigeration, I'd been trying to keep the film chilled with ice cubes in plastic bags. But the ice melted and the bags leaked. The result was a brew which, if not iced tea in the strictest sense of the word, certainly had the proper temperature and color as it dribbled out of the camera.

Messing Up Star Trails

While perhaps only the advanced astrophotographer can achieve camera submersion, even raw beginners can learn to waste film and damage expensive equipment. Consider, for example, what can be made to go wrong with so simple a shot as a star trail photo: the camera can be focused at 3 feet for a field whose nearest object lies at a distance of 11 light-years, the lens cap can be left on, the cable release can be lost in the pachysandra, the lens cap can dew up, the f/stop can be set to f/22, and the camera can be operated empty. And, oh, yes — no budding astrophotographer should pass up the chance to kick the tripod while the shutter is open.

Messing Up Piggybacking

As you graduate from star trails to piggybacking your camera on a clock-driven telescope, certain new techniques should be mastered. Greasing the bottom plate of one's camera encourages the normal tendency of the camera to slip on the piggyback mount during the exposure, yielding the desired streaked star images rather than the ordinary, boring

round ones. You can also adopt a fine historical view on polar alignment — this consists of ignoring the fact that Polaris is now the pole star and aligning your scope on such once-and-future pole stars as Thuban or Vega. The combination of a camera slipping on its mount and massive declination drift from the polar misalignment will yield star images that resemble the wanderings of a drunken sailor.

For consistently miserable piggybacking results, not always achievable via misalignment and tripod-kicking, I recommend taking photos with Brand X, Y, or Z lenses at full aperture. These lenses can often be identified by their full-page ads in photo magazines claiming superior performance for a low, low price. These usually produce photos guaranteed to move rapidly from the "IN" box to the "OUT" box at the desks of editors of astronomical magazines. Connoisseurs, however, make fine distinctions among these lenses. A Brand X lens, for example, produces, near the edge of the field, star images that look like obese butterflies. On the other hand, star images from Brand Y lens may look like Rorschach blots, while Brand Z star images can vary from comet-shaped to blobs somewhat resembling earthlight on the Moon — but out of focus.

If all else fails and good photos seem imminent, take a wide-angle piggyback shot. Chances are good that the shot will include the telescope's dewcap,

How many ways can you mess up a photo? Well, you could insure that the film doesn't lie flat in the holder; you could also leave film chips stuck to the emulsion side. Then you can chop off the film frame raggedly. Next, drop the frame on the floor and step on it at least once. Don't forget to do a sloppy job of focusing. Last of all — be sure to let the frame stick to another film chip during development. Photos by the author.





perhaps illuminated by a neighbor's porch light and looking like a plastic sunrise.

Messing Up Telescope Photos

As one moves on to guided through-the-scope photography, skilled practitioners prefer more subtly ruined photographs to the empty-camera and tripod-bumping methods favored by the star-trails and piggyback set. But this shouldn't be too daunting since the more elaborate equipment you need for guided through-the-scope photos provides rich and varied opportunities for botching. A guided photo, for example, can be turned into a star-trail photo by the simple expedient of disconnecting the telescope's extension cord. An intermittent short in the wiring of an illuminated guiding eyepiece, peered into by an optimistic photographer who thinks he can guide without crosshairs, produces drunken-sailor star images rivaling those produced by the misaligned and tripod-kicked piggybacker. Similar results are achieved if, on a damp night, the photographer exhales on his guiding eyepiece, producing the "bathroom window" effect and freeing the guidestar to move about unseen and unimpeded by corrections.

The astronomical literature recognizes certain types of double stars: visual binaries, optical doubles, and spectroscopic binaries. To these must be added foot binaries and nose binaries, produced in a manner you can probably figure out for yourself.

Mess-ups of the Mind

Among the more rewarding kinds of ruined deep-sky photos are those produced by mental lapses rather than by mechanical failure or clumsiness. Photos of the wrong area of the sky can result from forgetting the proper coordinates of a deep-sky object or, even more interesting, moving the setting circles rather than the telescope to the object's proper coordinates. Photographing such objects as Messier 40 or "Healy's Comet" (light-struck film) fall in the mental mess-up category.

One of your author's more creative botches was his photograph of the spiral galaxy M33 in the constellation Triangulum, carefully guided for an hour and fifteen minutes. Since, however, the shutter dial on the camera had been left on $\frac{1}{125}$ second rather than B, all the careful guiding was done with the

Admittedly less of a virtuoso performance than the Horsehead photo a page back, this shot of "Healy's cluster" still has a certain *je ne sais quoi*. In fact, if you photograph Regulus several times over on the same frame, altering the focus setting between each shot and offsetting slightly, you'll get something that looks about like this, which the author calls "Reguli."

shutter closed. I figure that this $\frac{1}{125}$ second shot was underexposed by a factor of 562,000 — putting it right up there with the film-free camera as one of the major accomplishments of amateur astrophotography.

Messing It Up With a Schmidt

But nothing can beat a Schmidt camera for the sheer diversity of potential errors. On page 17 you can see one photo that combines six major glitches and a host of minor ones — all produced by me while trying to photograph the Horsehead Nebula and the region around Zeta Orionis.

First of all, the film chip didn't lie flat in the film holder, producing on the top of the photo, out-of-focus star images that look like lamp shades seen from above. Next, the oval-shaped UFO at the top center is probably the spot where the film chip stuck to another in the developing tank. The dark triangle on the left edge is a trimmed off chip of film that stuck to the frame, probably during exposure. The top left corner of the film frame was trimmed away. The negative is scratched, dusty, and the film's anti-halation backing was not completely removed during processing. The whole photo is slightly out-of-focus because I used the Schmidt's filter film holder for taking this non-filtered photo.

I find it hard to believe that I produced this veritable festival of astrophotographic blunders, by accident, while cold sober. But here's a hint: do it at the end of a long photo session when you are very tired. Unless you go to such lengths, you'll probably combine only three or four mistakes into a single photo.

The Best Mess-up

In conclusion, I must disclose that I have never actually taken any good astrophotos. Some day I hope to. The photos in books and magazines carrying my credits I actually bought from observatory photo catalogs. The nearest I've come to a good photo is the multiple exposure of Regulus (Reguli?) and vicinity that's included here. Each of the multiple exposures was taken with a slightly different focus setting — an attempt to diagnose and cure a focusing problem with a new telescope. It's not good photography but who knows, it might be good art!

While good deep-sky photos will doubtless remain out of reach for all of us, we can nonetheless look forward to increasingly creative and bizarre mistakes. In this way, deep-sky photography can become a satisfying hobby without actually producing any results.

David Healy is Vice President of Drexel-Burnham-Lambert, a major brokerage house in Manhattan. He is a highly accomplished astrophotographer and a long-time contributor to Deep Sky.

ASTROPHOTOGRAPHY

Deep Sky Sketchbook

Dear Reader:

A new addition to DSM, "Deep-Sky Sketchbook," will appear periodically in these pages and feature some of the nicest sketches sent in by readers. I anticipate receiving your sketches for possible inclusion.

This first installment contains galaxy impressions made by Dan Troiani of Chicago, using his 10-inch reflector.

Yours Truly,

D. Eicher

NGC 5907
123x

NGC 150
123x

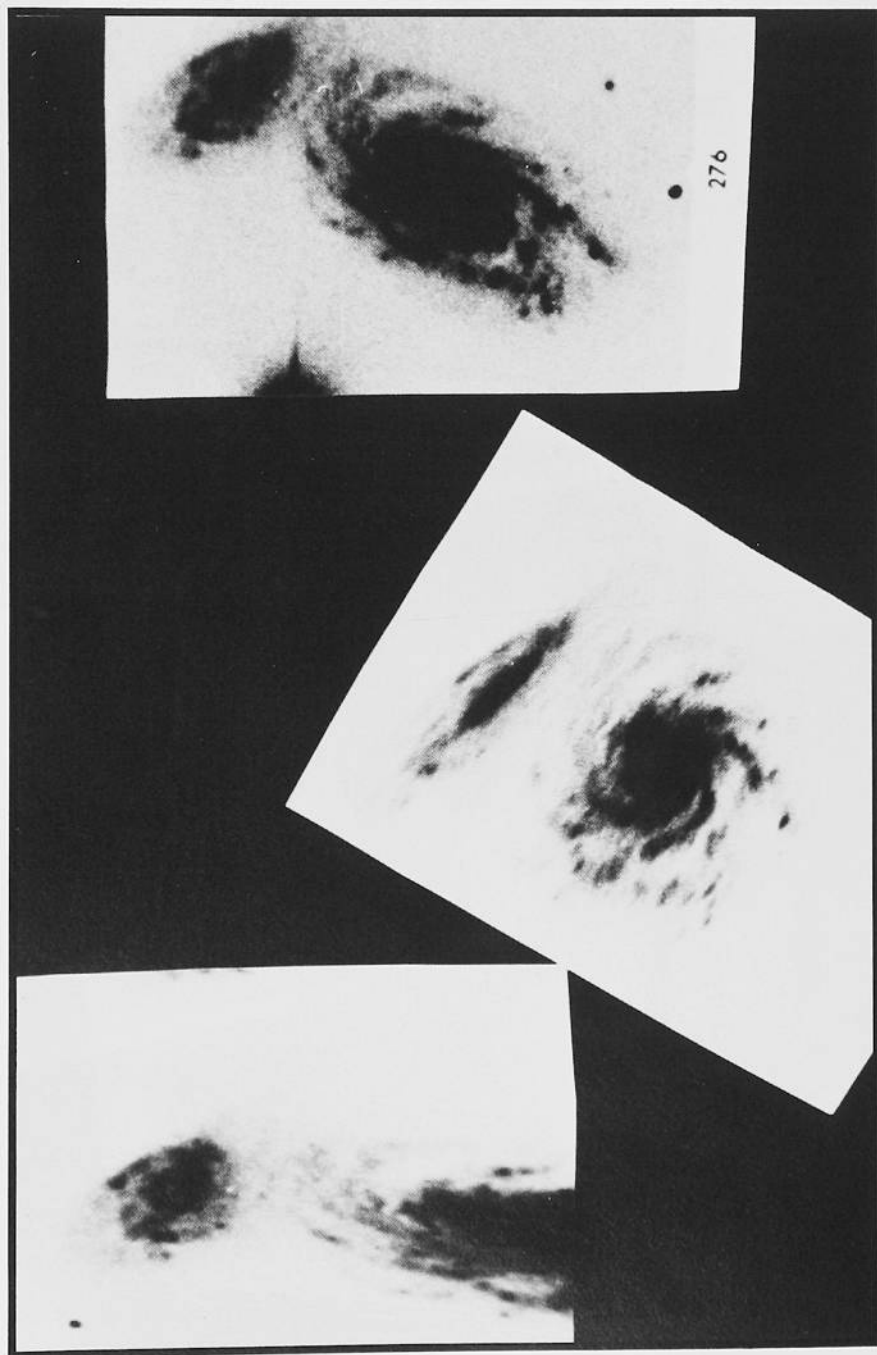
NGC 274 and NGC 275
123x

NGC 474 and NGC 470
168x

M102
123x

Tilting Spiral *Galaxies*

by Alan Goldstein



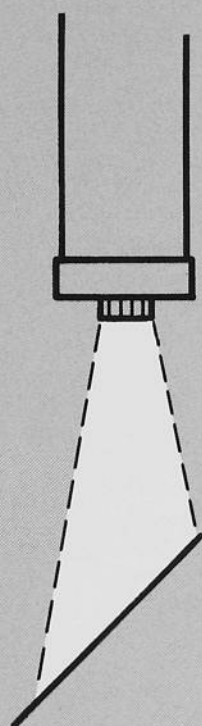
Astronomers who study the physical aspects of spiral galaxies generally work from two perspectives: edge-on (inclination = 90°) and face-on ($i = 0^\circ$). But most galaxies you see occur at an angle in between; these galaxies can frequently be "corrected" to approximate their face-on appearances.

Correcting spiral galaxies can provide an astronomer with a good account of the distribution of HII emission regions, stellar associations, and supernovae. The overall shape and structure of spiral arms and possible subtle changes due to interactions with neighboring galaxies can also be determined.

In 1978 I decided to attempt to correct a couple of galaxies from the *Atlas of Peculiar Galaxies* by Halton Arp. The galaxies I chose to rectify turned out much better than I imagined. I was hooked! Over the next three years, using the University of Louisville's Moore Observatory facilities (for which I am very grateful) and my own darkroom, I succeeded in rectifying nearly four dozen galaxies. Their inclinations ranged from 31° (NGC 6946) to 89° (NGC 7640).

It did not take long before I ran across other works on rectified galaxies. The first was Arp's corrected photograph of the Andromeda Galaxy, showing its arm structure and the distribution of globular clusters (*Astrophysical Journal*, **139**, 1045, 1964). Later, I encountered a master's thesis on NGC 1300 at the Indiana University Library in which the author corrected this galaxy. Timothy Ferris' book *Galaxies* shows M81 rectified. William Pence corrected NGC 253 and compared its rectified image with the unmodified image of Messier

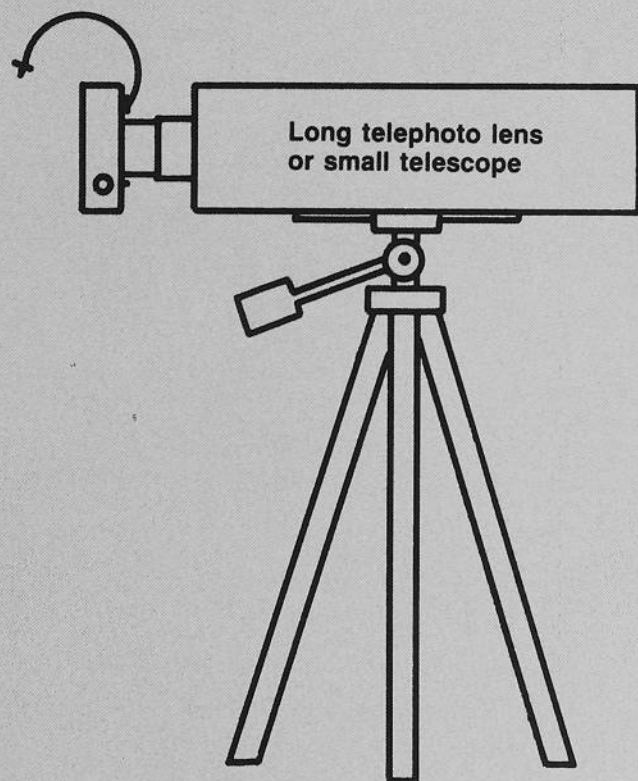
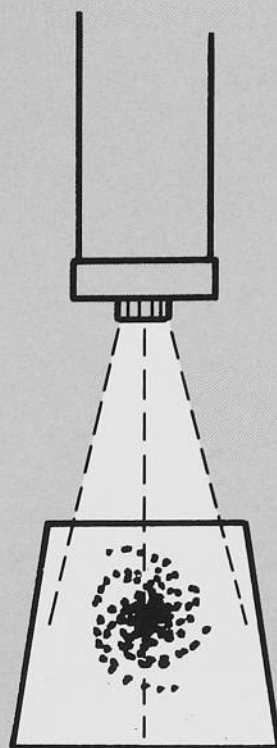
Arp 276 (NGC 935) tilts 50° to our line of sight; its companion, IC 1801, also tilts 50° . By projecting their images onto a tipped board and re-photographing them from "above," you can see what they really look like.



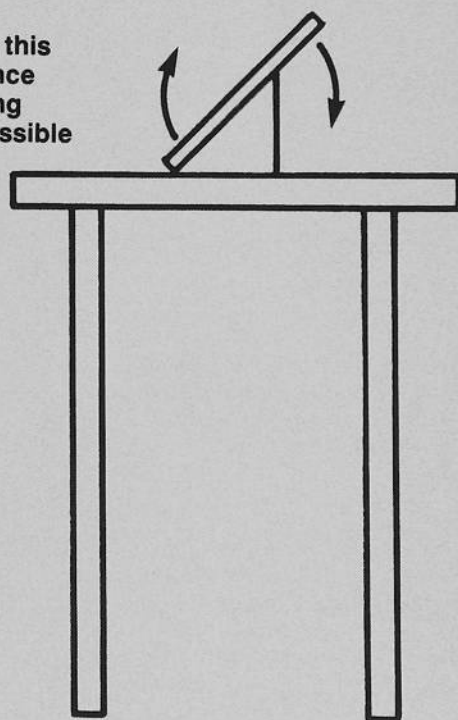
Enlarger

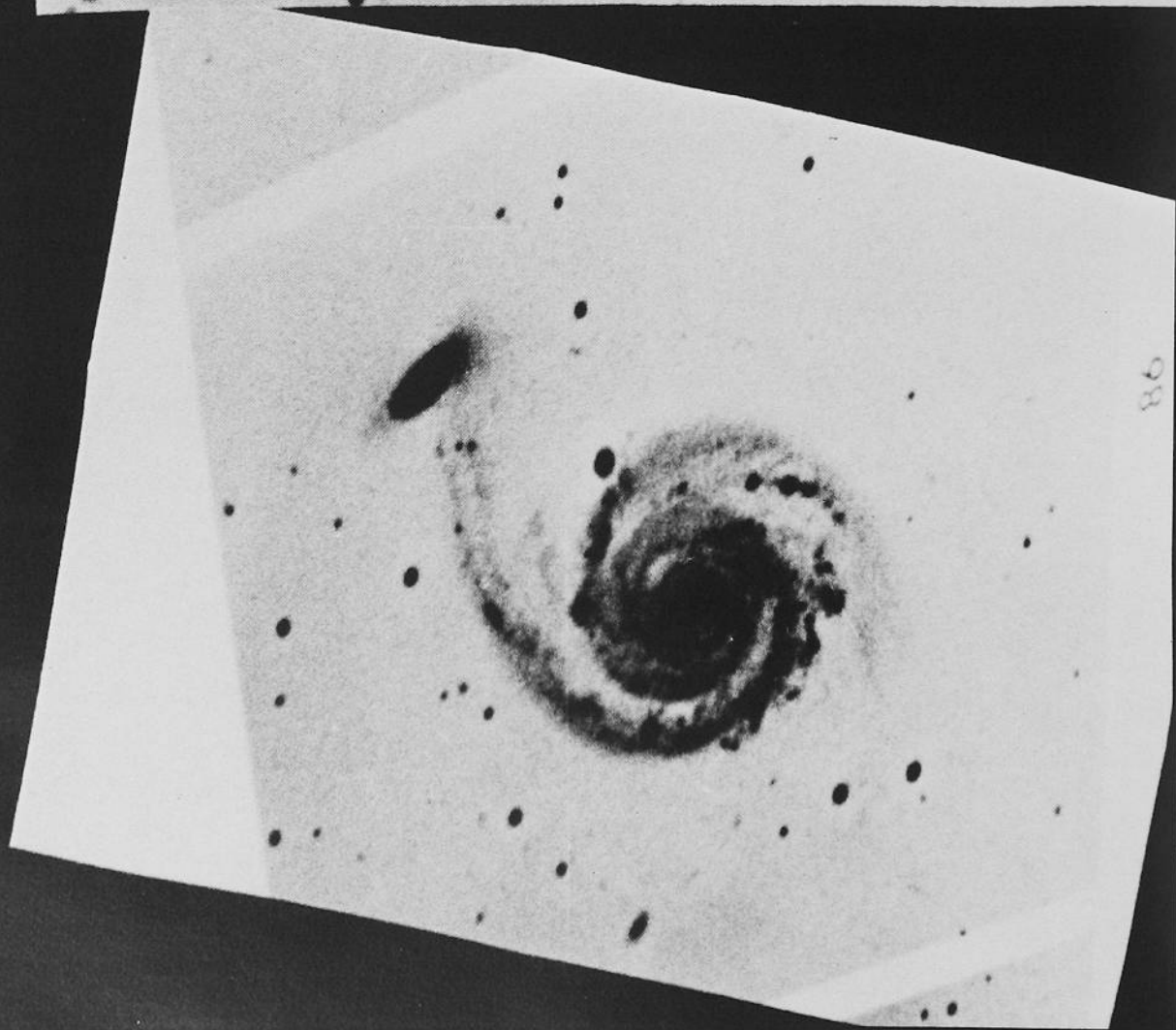
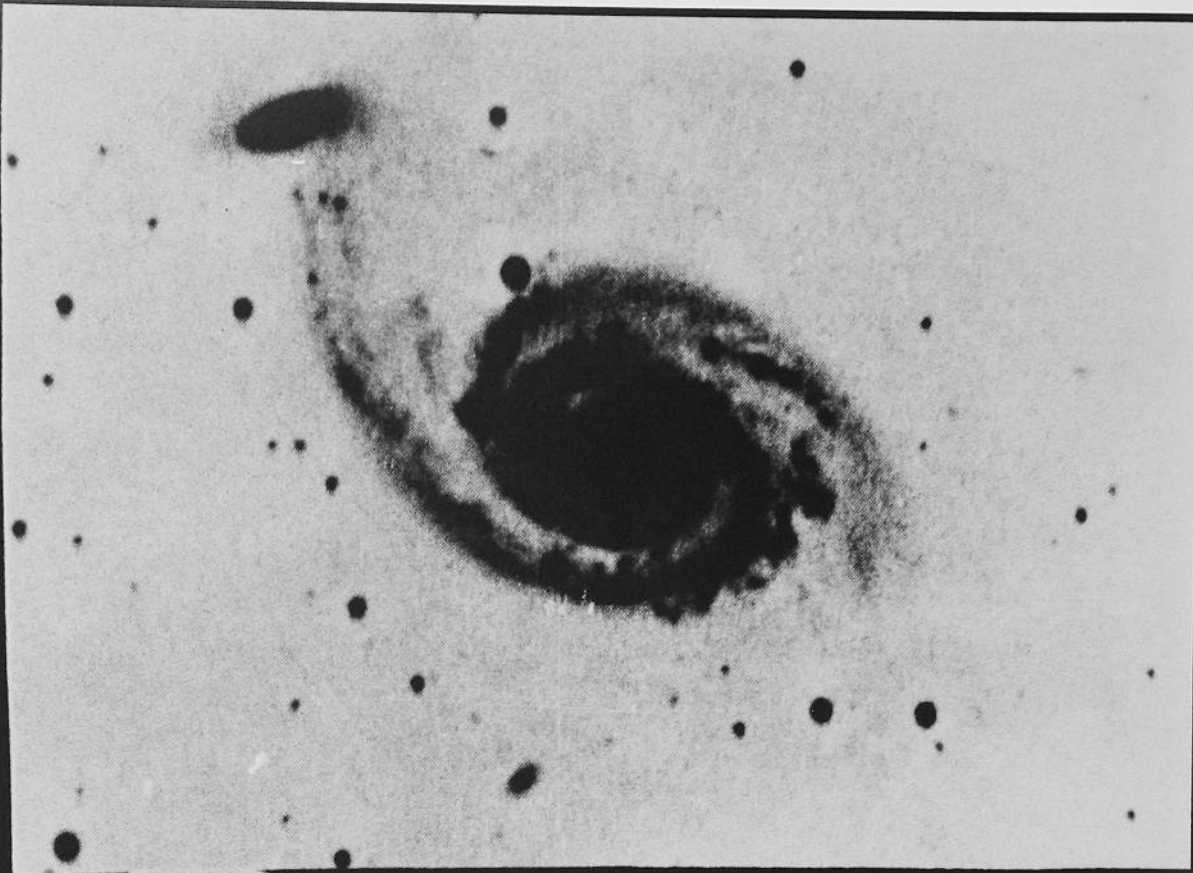
Take the negative of a galaxy and place it in your enlarger, then tip the easel and rotate it to "untilt" the galaxy. Next, re-photograph it from a distance — the farther the better to eliminate keystone distortion. Galaxies whose images have been rectified can be studied to reveal things like the structure of their spiral arms and the distribution of star clouds and HII regions.

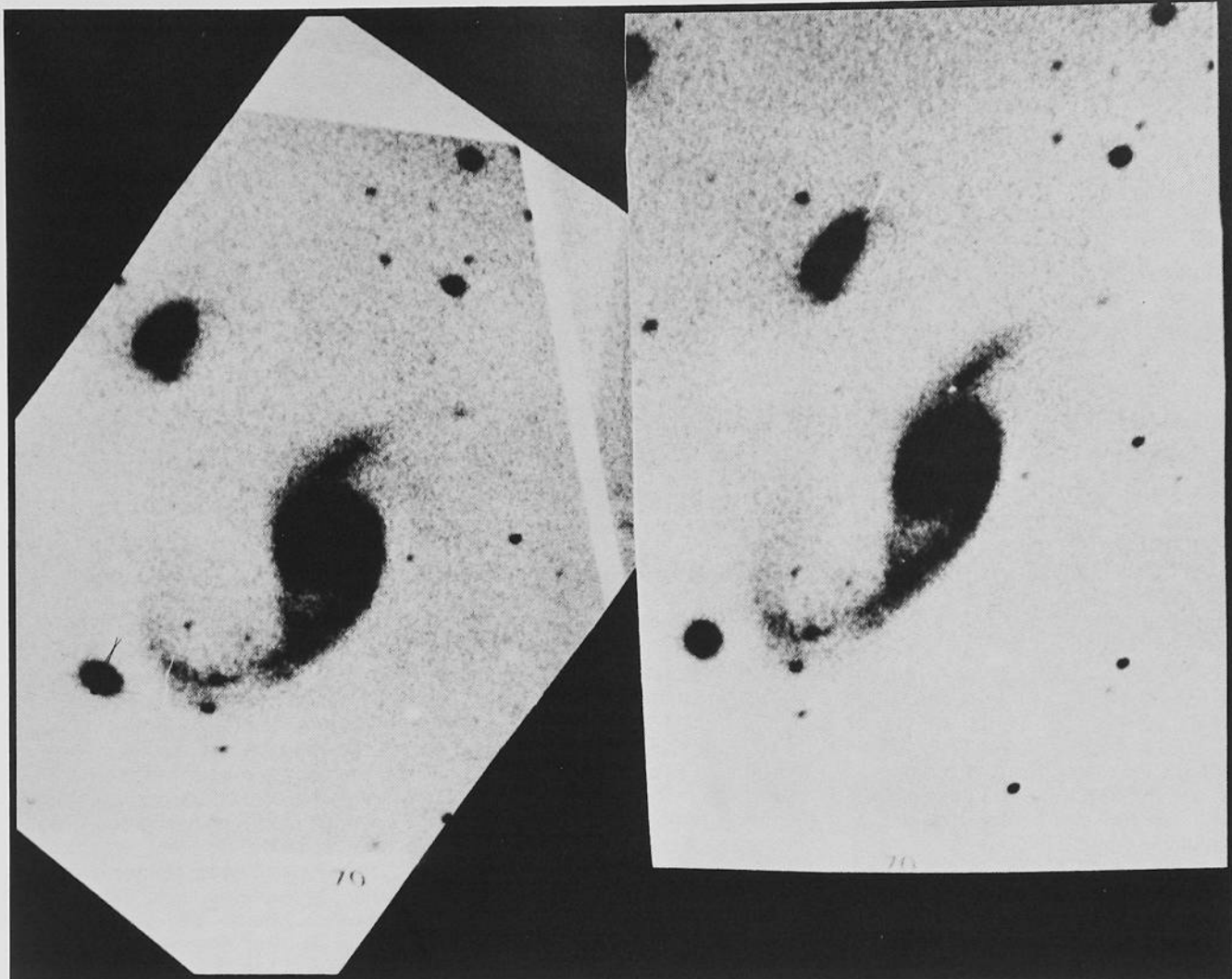
Easel



Make this distance as long as possible







Left: Arp 86 (NGC 7752) is distorted by the nearby galaxy NGC 7753. Above: Arp 70 and an anonymous companion galaxy. All photos by the author using Halton Arp's *Atlas of Peculiar Galaxies*.

83. R. Wright illustrates eight rectified spirals in an article discussing the aspects of reclassifying galaxies upon correction.

I call my technique the "phone book and brick" method because that's what I frequently use in the darkroom to keep my easel correctly positioned. I eventually intend to build a rotating easel, so the correction angle and azimuth — the "front" (closest edge) of the galaxy — can be measured. I used photos from Arp's *Atlas of Peculiar Galaxies*, and Kitt Peak and Palomar Observatory slides.

I took galaxy inclinations from articles on specific galaxies, a paper by Morton S. Roberts ("Integral Properties of Spiral and Irregular Galaxies," *Astronomical Journal*, 74, 859, 1969), and good ol' trial and error. I used a circular target for correcting the galaxies, since most have a circular outline. However, this isn't the case when a galaxy interacts with others.

With interacting spirals, the target is the center of the galaxy which is not as distorted as the outer arms. Some galaxies are easy to correct: NGC 772, M81, NGC 2903, Arp 8, and Arp 276 are good examples. On the other hand, galaxies like Arp 7, Arp 44, Arp 70, and Arp 273 are much more difficult because their arm structure is contorted.

A problem created by tilting the easel is "keystoning," where the photographic image is compressed at the top and expanded at the bottom. This tends to induce mild image distortion, but is not conspicuous unless the galaxy inclination is greater than 60° or 70°. A technique described by Gerard de Vaucouleurs avoids this problem somewhat. Tip the easel to rectify the galaxy image, then rephotograph it from some distance away using a long-focus telephoto lens or small telescope. This reduces the keystone effect.

Getting sharp focus for the entire image is an unsolved problem, but can be relieved partly by stopping the enlarger lens down to f/11, f/16, or f/22. Exposure times vary from 25 seconds to more than 100 seconds depending on inclination, negative density, and the

f/stop selected.

When you have a good rectified image of a galaxy, compare it to the non-rectified photograph to study arm structure, the distribution of HII regions, and peculiarities and similarities with other galaxies. Looking at special examples, galaxies like M81 and NGC 2903 ($i = 55^\circ$ and 70° , respectively) are easily rectified. Those less than 40° are usually not worth the trouble because the resulting changes are minor. Galaxies with an inclination of 80° or greater are challenging and can provide very interesting results if the arm structure isn't too tightly wound (e.g., NGC 7640). Those with dark or weak arm structure (e.g., NGC 4565 or NGC 3432) cannot be rectified.

Photographic rectification of tilted spiral galaxies can yield surprisingly good results — I've included only the best or most interesting examples here. Give it a try!

Alan Goldstein has contributed articles to *Deep Sky* and *Deep Sky Monthly* since the premier issue of the latter in 1977. He is founder of the National Deep Sky Observers Society (NDSOS) and an expert observer specializing in galaxies.

DSM Reports

Taking Note

by Brian Skiff

So you've found this planetary nebula. You are certain this must be it, because the spot is bright and has a much larger disk than the surrounding stars. Now what? Don't just say to yourself: "Okay, I've got it — I'll go on." Take notes!

There are good reasons for doing this. First, taking notes provides a record of your observing. This enables you to compare later observations with earlier ones in terms of different instruments, sites, conditions, etc. as well as with other objects. Second, you can use an accurate observation or sketch of an object and the surrounding field to identify the object on an atlas or photograph. Third, relevant details about an object visible in the scope helps in observing them.

What notes should one take? There are no set rules, so what follows is simply my own system. I developed it over several years with the aim of including enough information to make a crude pencil sketch of the object merely from my notes.

Most amateurs write their notes on paper using a dimmed and reddened flashlight. This is necessary if you plan to make a drawing of an object, but I prefer to dictate notes and comments into a cassette recorder. The principal advantage here is that you need no lights to operate the switches on the machine, thus preserving your dark adaptation. Even in the darkest locations, there is enough skylight to find your way — just as you distinguish your eyepieces in the dark by their sizes and shapes. A corollary advantage is that a second look in the eyepiece to check the orientation or brightness of a star can be made right away, rather than waiting for the after image of even the faintest flashlight spot to fade.

The only real disadvantage of dictating notes into a tape machine is the possibility of the cassette jamming. You can well imagine the frustration of losing half a night's observations because of such a malfunction. Despite boastful claims by the makers of blank tapes that their cassettes are jam-proof, you should occasionally keep an eye on the progress of the tape during the night with a flashlight while looking at your atlas. You may also be surprised at how long it takes to transcribe your commentary for filing.

There are 11 important questions to ask yourself about objects you observe. Although not every one applies to every

type of object, keep them in mind. They are:

1. What is the angular diameter?
2. Is the object more or less circular? If not, what are the maximum and minimum dimensions?
3. What is the position angle of this elongation?
4. Are there any distinguishing features?
5. How does the brightness vary across the object?
6. What is the magnitude of the brightest star or few brightest stars within the object's diameter?
7. How many stars are visible within the diameter?
8. Are the stars concentrated toward the center?
9. Are there gaps in the distribution of the stars?
10. To what extent are stars visible?
11. Is the central star visible?

Questions 1 through 5 clearly apply to all objects, whether starry or nebulous. The next five apply specifically to open and globular clusters. Number 11 obviously pertains to planetary nebulae.

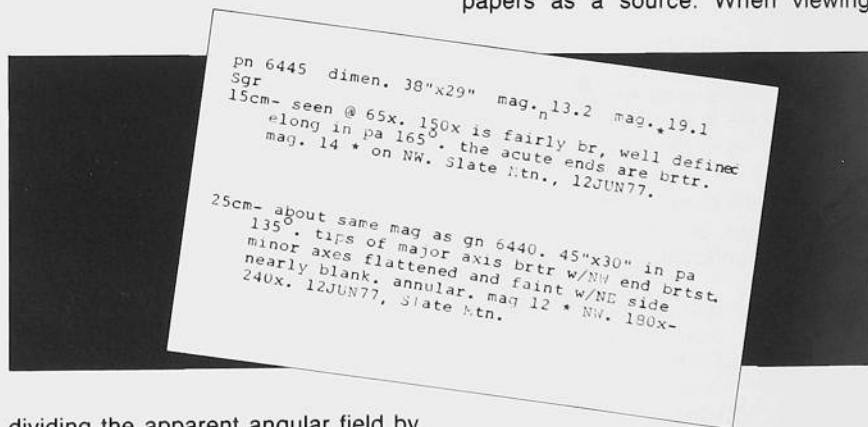
Dimensions are important measures in visual observing. You can determine them fairly accurately simply from knowing the angular field of your eyepieces. You can compute this by

Barlow, the eyepiece has a field of 46'. If you use this procedure, make several timings and use the longest consistent value in your calculations.

Angular dimensions of "unknowns" can be estimated by determining what portion of the field the object covers. If a cluster subtends one-fifth of our 23' field, then it is about 4.5' across. Remember that with Erfle or Konig eyepieces (with apparent fields on the order of 65°), the proportions tend to be overestimated: what seems like 1/3 near the center of the wide field is more often 1/5 if you actually move the object to the edge of the field.

For smaller objects, the best way to estimate sizes is to get a good mental picture of some double stars of known separation. Three or four pairs with separations of about 10", 15", 30", and 90" should be viewed occasionally at the start of an observing session to "calibrate your eyeball."

Magnitudes are another problem. Whereas the eye can judge proportions very well, it is a notoriously poor judge of brightness. The best procedure is to check fields of stars with known magnitudes just as you would double star separations. The large scale AAVSO charts are good for this purpose. For magnitudes of open clusters, I use data from professional papers as a source. When viewing



dividing the apparent angular field by the magnification of the eyepiece. Except for a few brands, I don't trust advertised claims for the apparent fields of eyepieces.

Barring exact knowledge of either apparent field or magnification, timing the transit of an equatorial star is the best way to find the true field of an eyepiece. The field in arcminutes is equal to the number of seconds needed for the star's transit divided by four. Example: for a medium power eyepiece, say a 20mm ocular +2x Barlow, the star may take 1 minute and 32 seconds (or 92 seconds) to cross the field. So the field is 23 arcminutes. Without the

them, it is perhaps a good idea to determine your limiting magnitude and the apparent difference between one magnitude and the next, as well as the apparent brightnesses of each magnitude. Using this technique, you can pretty well estimate magnitudes and half magnitudes. We are not worried about "absolute" photometry as with variable star work; it is important mainly to give an idea how difficult a star is to see in a particular telescope.

Position angle is simply the compass orientation of an object that starts at 0° (for north) and increases eastward

DEEP-SKY OBSERVATION FORM

H.G.C./I.C. NO. N147
 MESSIER NO. _____
 NAME (if any) _____
 TYPE OF OBJECT DE galaxy
 DEGREES ABOVE HORIZON M31 core?
 OTHER DATA _____

OBSERVER D EICHER
 ADDRESS _____
 OBSERVING SITE NEAR MICHIGAN, MI
 ADDRESS _____
 ELEVATION _____
 DATE (U.T.) _____
 TIME (U.T.) _____

View object with low, medium and high powers, give your full description below:

LOW POWER FIELD DRAWING
 Include fieldstars for identification

HIGH POWER DRAWING
 Look for any additional details

CONSTELLATION _____
 RIGHT ASCENSION _____
 DECLINATION _____
 MAGNITUDE _____
 SIZE _____
 SEPARATION (if app.) _____

TELESCOPE MAKE & TYPE _____
 TELESCOPE APERTURE 5.5 FOCAL LENGTH 74.3
 FILTER _____
 SEEING (0 Worst - 10 Best) _____
 TRANSPARENCY (0 Worst - 6 Best) 6
 TEMPERATURE Cold as Hell
 HUMIDITY _____

MAGNIFICATION preliminary drawing
 VISUAL RATING - Check one:
☐ VISUALLY IMPRESSIVE, A FAVORITE
☐ VISUALLY ATTRACTIVE
☐ RESOLVED, BUT NOT IMPRESSIVE
☐ BARELY DETECTABLE, NOT INTERESTING
☐ DETECTABLE ONLY WITH EXCELLENT SKIES

BEST OVERALL MAGNIFICATION _____
 Shut off clock drive, indicate direction
 Use pencil for drawing so that -

PHOTOGRAPHIC NOTES:
D. Eicher

1 Oct 83
 (Kankakee, IL)
 NGC 147
 17.5" f/4.5
 32mm ~65x

30cm - 5' W of unequal pa 0° dbl *. along N-S w/
 strikingly acute points, particularly N one,
 which is almost *.ar. * just off NW edge.
 217x interesting: like a miniature N27, but
 lobes actually in pa 160° w/dark area between.
 faint irreg outer haze is in approx pa 45°.
 uneven texture, diffuse edges (more so than
 N27). Neat! br area in NW lobe is multiple
 @ 217x. Roof, 10MAY77.

row or (p).
 shaded.
 (N Form #2)

around the compass to end at 360°. East is 90°; west is 270°. With narrow objects, you can estimate this angle by eye to within 10° or 15°. Double star observers use the entire circle, noting the orientation of the fainter component in relation to the brighter one. However, for symmetrical objects such as galaxies, I always take the lower of the two possible values: an elongation of p.a. 60° to 240° is recorded as 60°.

Some things cannot be reduced to a convenient number, but remain matters of judgment. It is a simple although tedious task to count the number of stars visible in an open cluster, but how else can we describe the way they are concentrated toward the center? Or the color of an outstanding star?

Over years of observing, I have worked up a set of terms to be consistently applied to each type of deep-sky object. Globular clusters and galaxies tend to be radially symmetrical objects. The typical globular cluster

rises smoothly in brightness to a very small, very bright "nucleus." Often around this is a "core" of lesser but nevertheless high brightness. At the edge, the stars thin out and sometimes produce a hazy, dim "halo" around the cluster. Depending on aperture and magnification, a globular is "unresolved," "grainy," "partially resolved," or "well resolved." Galaxies resemble globulars in their apparent visual structure: usually there is a tiny bright (sometimes "stellar") nucleus in a larger, less bright core surrounded by a diffuse halo. Of course we can hardly expect to see individual stars with an amateur instrument, but it is not at all unreasonable to see giant star clouds, HII regions, and globular clusters in the brightest objects. Often an HII region will appear visually as a faint star superposed on the halo of a galaxy. Later checking of a photograph can confirm this if we have noted how far and in which direction it lies from the center of the galaxy. It is this sort of observation which gives me satisfaction:

My eyes weren't fooling me, I saw something real!

After my night of observing, I transcribe my taped notes onto paper. This is kept as the "hard copy" for future reference. I take down the details in just the way I have dictated them, never rearranging for clarity. For previously unobserved objects, I collect data from various sources and copy these onto sheets of paper. Then everything is typed on unruled 3" x 5" index cards. Across the top is a legend containing pertinent data and below are little paragraphs about the observations. Despite many abbreviations, these often continue onto the back of the card. At the bottom of the front side, I generally place comments from various catalogues and photographic sky atlases. Originally, the cards were sorted by type of object, but soon it became more convenient to file them by constellation using a thumb-tab index card heading in order of right ascension within each constellation. Observations are identified by date and location. If several observers contribute to such a card catalogue, it would be wise to include initials of the observer as well.

A good ploy is to ignore "published" sizes and magnitudes of objects before observing an object. In many cases, particularly with open clusters and planetary nebulae, your estimate of the diameter or the total magnitude will be closer to the truth than what is in this or that catalogue. In the case of galaxies, I find the observed sizes compare well with those of the Shapley-Ames catalogue (as it appears in the *Atlas of the Heavens Catalog*), but very much smaller than the rigorously-defined photometric measurements in the *Second Reference Catalogue of Bright Galaxies* by Gerard de Vaucouleurs *et al.* The Shapley-Ames galaxy magnitudes are consistent but have a systematic error as a function of the size and type of galaxy. Those of de Vaucouleurs, however, are tied to the standard system. Do not be surprised if you are able to find objects which are nominally beyond the magnitude reach of your scope. I tend to stop looking for galaxies at a blue magnitude of 14.2 to 14.5 with a 10-inch scope at high power where the limiting stellar magnitude is about 14.8. Yet I have found at least one object with a blue magnitude of 15.7, and many in the range 14.5 to 15.5.

Taking notes really pays off. It allows you to compare old observations with new ones and build a reference "travelogue" of sights you've seen in the sky. If you don't already keep records or sketches of deep-sky objects, consider starting now. It will open your eyes to a whole new way of observing.

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The Case of the NGC 6962 Galaxy Group

by Steve Gottlieb

The *New General Catalogue (NGC)* by J.L.E. Dreyer, published in 1888, is a compilation of over 7,840 deep-sky objects previously recorded by a number of visual observers — most importantly, William and John Herschel. During the 97 years since publication of this catalogue, it has become the standard reference for deep-sky objects. However, many of these objects were not independently checked and verified, so a number of nonexistent objects, duplicate entries, and positional errors exist. Dreyer caught some of the mistakes and published corrected information as appendices in the two *Index Catalogues (IC I and IC II)* in 1895 and 1908.

More modern photographic surveys, such as the Palomar Observatory's *Sky Survey (POSS)* of 1950-1956 — made

with my 13.1-inch f/4.5 reflector operating at 166x. Using a 9mm Nagler eyepiece, the 30' field showed six galaxies (see sketch). I made the following descriptions of their appearance:

A. The fourth brightest of six galaxies is fairly faint, very small, and appears to be nearly edge on. The elongation is northeast-southwest and an arc of three equally bright stars is located just to the southwest.

B. The most difficult to observe of the lot. It is extremely faint and requires averted vision to see. No details are visible other than the galaxy's very small size — it is just a nebulous knot 10' north of D.

C. The third brightest is a spiral elongated in an east-west direction. A magnitude 10.5 star lies less than 1' to the east and interferes with viewing. The only noticeable detail is a slight brightening in the galaxy's center.

D. The brightest and largest in the group. This galaxy is fairly bright, slightly extended, and has a noticeably

The NGC 6962 Field: An Identity Crisis

Object	RNGC	CGCG	UGC
A	6965	6959	6959
B	6963	6963	6963
C	6967	6967	6965
D	6962	6962	6962
E	6964	6964	6964
F	6961	6961	6961
G	6959	—	—

using the 1.2-meter Palomar Schmidt — provided a more reliable check on the accuracy of *NGC* entries. Capitalizing on this, in 1973 astronomers Jack Sulentic and William Tifft used the *POSS* plates to photographically identify *NGC* objects, provide accurate coordinates for epoch 1975.0, and give modern descriptions based on each object's photographic appearance. Their published work was titled the *Revised New General Catalogue (RNGC)*. In cases where no identifiable object was spotted within 5' of the original position, the object was dubbed "nonexistent" and categorized as Class 7. Unfortunately, the compilers of the *RNGC* and other modern catalogues were sometimes misled in their identifications by previous *NGC* errors in description and position, making it necessary to refer to the original sources to identify what's going on.

I recently ran across just such a discrepancy in the modern catalogues concerning the identities of members of a small group of galaxies in Aquarius, whose brightest member is NGC 6962 with a V magnitude of 12.0. I observed this little galaxy group on the morning of July 28, 1984 in the California Sierras

brighter core. A wide pair of stars collinear with D is 3' west. D is flanked by the fainter galaxies E and F on either end.

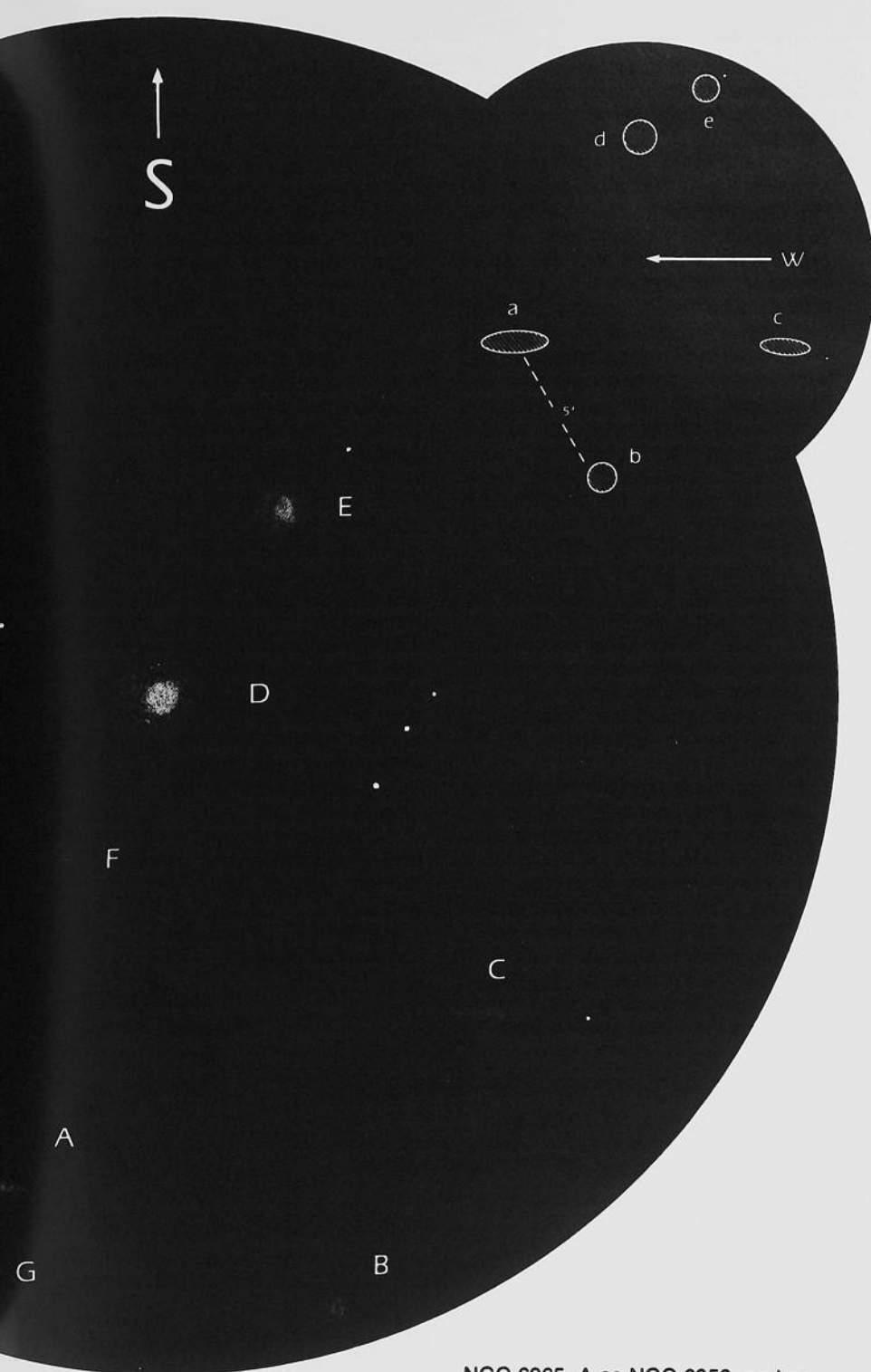
E. Just 2' southeast of D is the second brightest galaxy in the field. It appears moderately bright, small, slightly elongated north-northwest/south-southeast, and has a slightly brighter nuclear region. A magnitude 13.5 star is located less than 1' southeast.

F. Similar to B, although possibly easier to view. It lies about 3' northwest of D. With averted vision, it appears as a round, hazy spot only 15" or 20" in diameter. As with B, I cannot detect any detail in this galaxy.

To help sort out this group of galaxies, I referred to the *RNGC*, the *Uppsala General Catalogue of Galaxies (UGC)* by Nilson, the *Catalogue of Galaxies and Clusters of Galaxies (CGCG)* by Zwicky, and the appropriate *POSS* print

Solving the Mystery

NGC	Object	Rosse	R.A.(2000)Dec.	Mag. (V)	Size
6959	A	a	20h47.1m +00°26'	~14.6	—
6961	F	—	20h47.2m +00°22'	~14.8	—
6962	D	d	20h47.3m +00°19'	12.0	3.0' x 2.5'
6963	B	b	20h47.3m +00°29'	14.1	0.7' x 0.7'
6964	E	e	20h47.4m +00°18'	12.7	1.9' x 1.4'
6967	C	c	20h47.5m +00°25'	—	—



Left: The NGC 6962 galaxy group sketched by Steve Gottlieb using a 13.1-inch f/4.5 Dobsonian at 166x. The galaxy marked "G" was added later after inspecting the Palomar Sky Survey plate of the area. **Inset:** The group sketched by William Parsons, Third Earl of Rosse, in August 1857. Parsons remarked of the NGC 6962 area, "a group of five nebulae, very many stars among them."

might be erroneous. He was confident that only the *CGCG* identified the other galaxies in the field correctly.

To pin down the source of the possibly erroneous *NGC* entry, I corresponded with Harold Corwin of the University of Texas at Austin. Corwin is a co-author of the respected *Second Reference Catalogue of Bright Galaxies*; he provided me with a copy of the Earl of Rosse's observations and a sketch of the field Rosse made in 1857 (see sketch).

In my sketch of the field, I followed Lord Rosse's lettering, so *a* = *A*, *b* = *B*, etc. (Object *F*, NGC 6961, does not appear in his sketch.) When he compiled the *NGC*, Dreyer entered Rosse's object *B* as NGC 6965, but with incorrect coordinates. This probably happened since Lord Rosse gave relative positions for members of groups rather than absolute coordinates. The correct position of object *B* was later given by M.G. Bigourdan of the Paris Observatory, and was entered into Dreyer's catalogue as NGC 6963. So, NGC 6965 is simply an erroneous duplicate entry of NGC 6963 and should be deleted from the *NGC* and assigned to class 7 in the *RNGC*.

Apparently in an attempt to identify some galaxy on the *POSS* print for NGC 6965, Sulentic and Tifft picked *A* (in actuality, NGC 6959) and then reassigned the name NGC 6959 to its companion galaxy *G*. In a similar vein, the *UGC* chose object *C* (actually NGC 6967). The correct identities, 2000 coordinates, magnitudes, and diameters are given in the accompanying table.

In a recent letter, Thomson wrote, "If errors of cataloguing for northern hemisphere objects can still be found today, considering the vastly larger amount of observations carried out as opposed to the southern hemisphere objects, then clearly those objects located in the southern skies must present an even greater probability of possible errors regarding the published data."

For the sake of our friends south of the equator, let's hope the old saying still applies and "taint necessarily so."

(serial #0-305). The following four were identified by all sources: *B* = NGC 6963, *D* = NGC 6962, *E* = NGC 6964, and *F* = NGC 6961. However, the identities of three nearby galaxies — NGC 6959, NGC 6965, and NGC 6967 — were disputed.

The coordinates given in the *RNGC* identified *C* as NGC 6967, *A* as NGC 6965, and *G* as NGC 6959. (The last galaxy, *G*, is an extremely small and faint object which I could not see, but which is located 1' northwest of *A*.) On the other hand, the *UGC* listed *C* as

NGC 6965, *A* as NGC 6959, and gave no entry for NGC 6967. Finally, the *CGCG* agreed with the *UGC* in that *A* was NGC 6959, but gave coordinates indicating that *C* was NGC 6967. The *CGCG* — complete to photographic magnitude 15.5 — does not list NGC 6965. (See the table for a summary of this identity crisis!)

When the *POSS* print itself did not solve the dispute, I wrote to California observer Malcolm Thomson concerning my observations. Thomson, an experienced observer and contributor to the Webb Society's *Deep Sky Observer's Handbook*, responded by saying the original entry for NGC 6965

A Look at S Persei

by Brian Skiff

In *Deep Sky* #8, David Levy suggested that readers watch S Persei, a long-period semiregular variable located near the Double Cluster in Perseus. Coincidentally about the same time that issue came out, I began monitoring the star photoelectrically during the course of other photometric work at Lowell Observatory. Here's a summary of the first season's results.

S Persei has an average spectral type of M4Iab, that is, it's an uncommonly cool supergiant. Not many other stars as luminous are also as cool (by "cool," we mean around 3000 K, compared with about 6000 K for the Sun). Nearby RS Persei, at the center of the χ Persei cluster, is one; VX Sagittarii, a star also on the AAVSO program, is another — however, it is so unusual that it may be a different type of beast altogether. The very common Miras are often much cooler, particularly at minimum, but also much less luminous, even at maximum. That "e" in the spectral type indicates that spectral features are seen in emission: H, OH, and H₂O (water!) are all seen as bright lines or bands in the spectrum.

The star has been observed since 1890 with hardly a break. The nature of the light curve is unique in that closely interfering periods appear to regulate variations in the star. As early as 1904, H.H. Turner analyzed the visual record of Sir Cuthbert Peek over a nine-year span, finding periods of 840, 1120, and 3360 days. In 1939, Leon Cambell quoted periods of 810 and 916 days derived by T.E. Sterne from the AAVSO record. The most recent analysis I can find is by Kam-Ching Leung and Richard Strothers. Using AAVSO data for the interval 1935 to 1961, they found two clear periods of 807 and 968 days. Lack of strict regularity in the star's variations and "noise" in the visual data probably means no period-finding analysis will fully account for the observations. Usually the light curve appears sinusoidal with pretty well-defined maxima and minima. But other features do occur. The stretch of data in AAVSO Report 38, for instance, shows the star drifting slowly between nearly stable plateaux of brightness, a phenomenon observed in other late-type supergiants.

Though S Persei has a typical range of 1½ magnitudes over its 2½-year cycle, my observations this past winter show a total range of only one-quarter magnitude. The measures were made with the 21-inch photometric telescope at Lowell Observatory. Two comparisons were observed with the variable differentially in the *b* and *y* filters of the Stromgren system. The data were

recorded in the pulse-counting mode on the small computer. The telescope and associated electronics are described in Russ Genet's *Solar System Photometry Handbook*.

The two comparison stars used are shown on the AAVSO chart in *Deep Sky* #8, reprinted here. The star marked "84" (HD 14415) just west of the variable is the fainter; the other somewhat brighter star (HD 14571) is unlabeled, but lies 30' south of S Persei. Like most of the stars on the chart away from the cores of η and χ Persei, neither have previous photoelectric measures. Fortunately, both are moderately red stars though still not nearly as red as S Persei. If we assume they are giants (likely) and unreddened by interstellar absorption (maybe), the photoelectric colors suggest HD 14415 has a mid-G spectral type, while HD 14571 is about K3 — about as red as you want to go and still expect a star to be constant. And by contemporary standards, both are. Their differential magnitude (magnitude of star A minus star B) has a standard deviation (rms scatter) of only 0.004 magnitudes in both *b* and *y* over six months' observation on 25 nights.

The light curves show the variation of S Persei (S Per minus HD 14415) and the constancy of the comparison stars (HD 14415 minus HD 14571) in the *y* filter where S Persei is about mag. 10.0. The plots in the *b* filter are similar except that the range of the variable is about 0.04 magnitudes larger due to a color change in the star (i.e., getting redder as it declines, thus fading more in *b* than *y*). The observations extend from 11

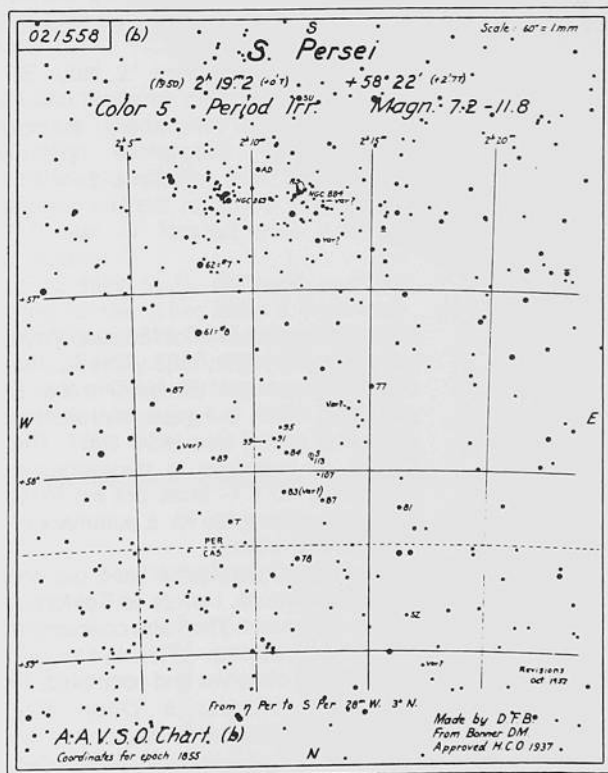
October 1984 to 25 March 1985. The large gaps are caused by persistent bad weather and demands on the telescope time. Regular observations at this level of precision every five to seven days would probably be sufficient to define the light curve very accurately. The trace shown here is smooth and unremarkable except that the rise this spring was more gradual than the decline last fall. The broad minimum is centered near JD 2446050 (15 December 1984 UT).

The next maximum could occur sometime in early 1986, when the star is well placed for observation. However, I hope to pick up S Persei again in the predawn sky by the end of June 1985 to obtain a fairly complete light curve. This is one case where a southern observing site is at a disadvantage compared to a northern one!

At the moment, I have no strong scientific rationale for observing S Persei. I liken it more to the bear going over the mountain to see what he could see. A thorough study would include spectroscopy or narrow-band photometry in addition to correlating the broadband variations with changes in temperature and luminosity. If the observations can be continued over several complete cycles, the structure of the star's atmosphere could be more accurately modeled and the mechanism for the unusual double-mode period uncovered.

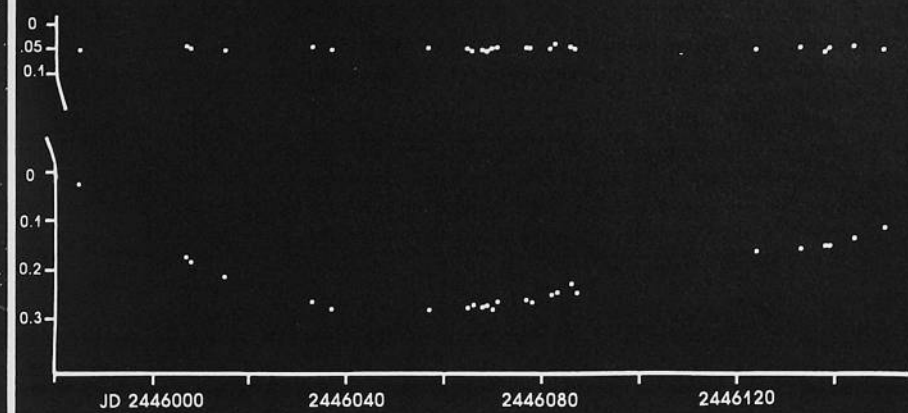
Meanwhile, it's enough fun just to watch what happens.

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Right: The Double Cluster/S Persei (circled) field photographed by Norman G. Thomas with the 13-inch f/5 "Pluto" camera at Lowell Observatory. **Inset:** Light curve for S Persei made by Brian Skiff. X-axis plots Julian Days; Y-axis plots arbitrary magnitude variance. Detached plot on top shows comparison star. **Left:** AAVSO finder chart for S Persei, courtesy Janet A. Mattei, AAVSO. Both Lowell photo and finder chart have south at top.

S Persei's Light Curve



Photographing Double Stars

by Anthony Gondola

If any part of amateur astronomical photography rates as the most ignored, it's surely double-star astrophotography. A quick look though the latest issue of any astro-publication reveals galaxies and nebulae by the score, lunar landscapes by the dozen, and planetary portraits in great profusion. But just try to find a good photograph of Mizar and Alcor or Albireo!

Whether for scientific measurement or purely aesthetic reasons, double-star photography opens new ground for astrophotographers to explore. Anyone who has produced a good photograph of the Moon can be successful with double stars. In fact, making a good photo of a pair such as γ Andromedae is a good deal easier than photographing the planets!

Equipment Requirements

You must have an equatorially-mounted telescope with a clock drive, but aside from that almost any type of telescope/optical system can be used successfully on double stars. The longer the focal length you have, the closer the pairs you can split, but there's no "free lunch" here: long focal lengths produce high image magnification which in turn mean that any shakiness or wobbling in the mounting will be readily apparent in your photos.

How short can you go for focal length? Obviously a 300mm lens will not resolve close pairs of a few arcseconds' separation. But that same lens will do a wonderful job on wider subjects such as $\alpha^{1,2}$ Cygni and α and β Capricorni. By the way, if you want to increase the focal length of your system, it's better to use a high quality photographic tele-extender first rather than a Barlow lens or eyepiece projection. This is because most Barlows and eyepieces will not project a flat field.

The following are a few points to keep in mind for success in double-star photography:

1. Have a focal length adequate to resolve the pairs you wish to record. Plan on going for pairs about twice as far apart as the Dawes limit for your aperture. (Dawes limit = $4.56''/\text{aperture}$ in inches.)
2. Use a drive that will produce round star images in unguided exposures as long as 30 seconds.
3. Take the trouble to get a good polar alignment — no declination drift for at least 30 seconds, either.
4. Use an exposure system with a vibrationless shutter.

Films

The ideal film for doubles has the following properties: high speed, so it can record faint companions with

relatively short exposures. Second, high resolving power and contrast, to make the images clear and crisp. Last, (if you work in color) it should reproduce the faintest tints with perfect fidelity! Now clearly no film can fulfill all of these requirements. However you can get good results with common emulsions if you plan a little beforehand.

The best choices in black and white are gas-hypersensitized TP 2415, Plus-X, and Tri-X. Your choice here depends on the size of your telescope as well as the separation and magnitudes of the pairs you wish to record. The basic rule of thumb is: use the film that is just fast enough to reach the pairs you want in less than about 15 seconds (see diagram).

For color, both Ektachrome 400 and 200 work well, although you should remember that color-seen is not color-photographed. Those wonderful hues you see in the eyepiece don't usually survive the translation to color print or slide because the film's emulsions and

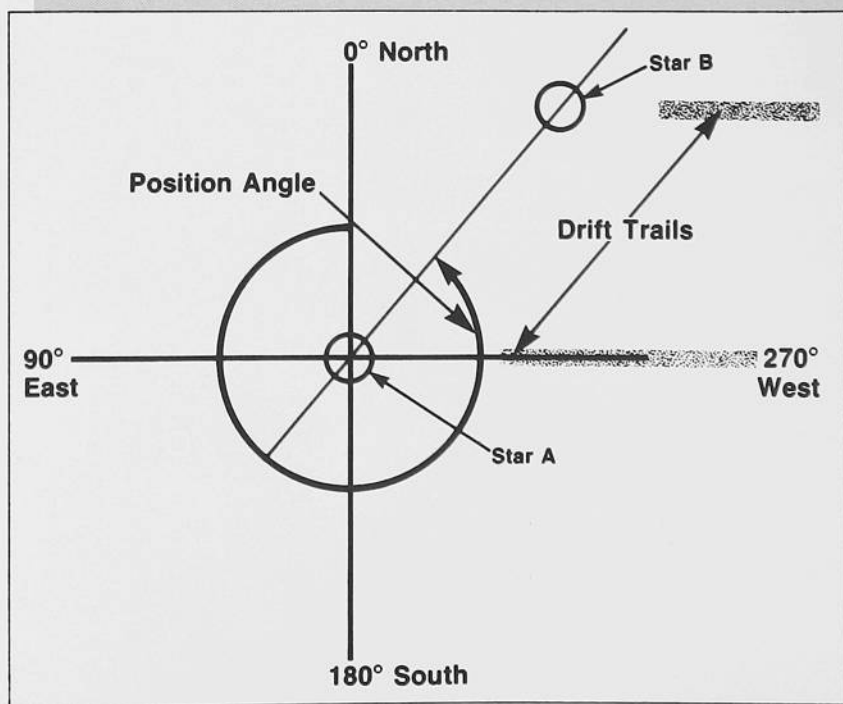
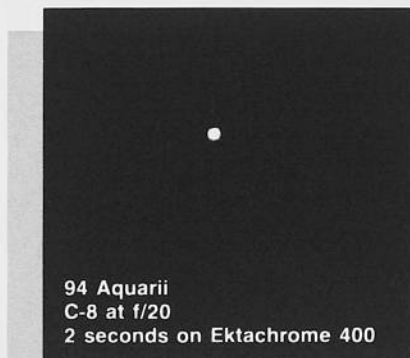
dyes don't have the same spectral response as your eye.

A note on processing: it's best to do all the darkroom work yourself. But if this isn't feasible, always ask that your film be left uncut and, in the case of slides, unmounted. This saves you a little money and prevents the photofinishers from chopping your frames in half accidentally.

Exposure Technique

OK, let's imagine that we are finally ready to begin. The correct film is in the camera, our mount is well aligned and the seeing is good to excellent, our logbook lies open and ready. The last barrier to good results is at hand: vibration, the ruin of probably more lunar and planetary photographs than you could ever guess. The easiest way to deal with this problem is not to use the camera shutter to control the exposure. Instead, treat the shutter as a dark slide to cover and uncover the film before and after exposure. The actual exposure is made by hand using a piece of matte black cardboard large enough to cover the full aperture of the telescope. Do it as follows:

After centering the double star in the viewfinder and focusing carefully (a focusing magnifier is a great aid here), cover the full aperture with the black card. Open and lock the shutter, making sure that the camera's shutter speed dial is turned to B or T. (All-electronic camera aficionados may have some difficulties with battery drain here — see your manual.) While still keeping the full aperture covered, lift the card an inch or two off the end of the tube and wait 8 to 10 seconds for all vibrations to dissipate. Then quickly flick the card out



of the optical path for the required length of time.

When the time's up, re-cover the tube with the card and release the camera shutter. This method *guarantees* no vibration will occur during the exposure. With very little practice you can make consistent exposures as short as 1/2 to 1/4 second by flicking the card.

Don't forget that even with a well-tested film/telescope combination bracketing your exposures is wise. Make a sequence of exposures running 1, 2, 4, 8, and 16 seconds for each pair you photograph. And keep a logbook, so that three weeks — or three years — from now you can know what you did tonight. Assign each roll of film a unique number and after processing enter the roll and frame numbers into the log where you recorded the exposures.

Double Star Measurements

Before we delve further, it's time to make an admission: photography is not the method of preference for keeping tabs on double stars. If precise measurements are your goal then visual observing with a micrometer is best. Under good seeing conditions, an observer can bisect the Airy disks of stars and measure their separation and position angle very accurately by eye-and-micrometer. With photography, however, you're limited to judging the centers of star images that are almost

haven't read it yet, go see the preceding article by Robert Argyle.)

Amateur double star observations have a status similar to amateur variable star observations. The visual observer of variables can't compete with professional photoelectric observations in terms of absolute accuracy — but this doesn't matter since you are gathering data for work on different problems. Any backyard observer who undertakes a program of double star measurement, visual or photographic, can contribute useful data.

Finding the Image Scale

The first step in measuring your photographs is to determine the image scale of your telescope at prime focus. This is done most accurately by photographing double stars with essentially fixed separations, such as β Cygni or δ Orionis. The resulting negative or slide can be measured directly using a microscope or magnifier fitted with a reticle divided to at least 0.1 mm (Edmund Scientific sells these). When measuring film, place a thin microscope cover glass over it to hold it flat. Repeat the measurement for three separate exposures and average the reading.

Once you have the image scale of your system, it's a simple matter to determine the separation in arc-seconds of all subsequent photographs made with the same optical set-up.

Position Angle Measurement

Before you can measure position angle, the 90°/270° east/west axis must be defined on the same frame that contains the image of the double star. The easiest way to do this is to let the Earth's rotation draw the line for you. After completing the driven exposure of the pair, turn the drive off and leave the tube covered for an instant. Then uncover it and let the star trail for a few seconds to half a minute before recovering and ending the exposure normally. After processing, the frame then will have the driven image and a nice trail of the pair extending off to the west. For the line to be accurate you must be sure that the drive stops smoothly without bumping the telescope in declination. (This technique will not work well close to the pole or for extremely dim stars — so avoid these stars.)

Print Measurement

If you don't have access to a measuring reticle, you can make readings directly from enlarged prints. This method has the advantage of giving a larger image scale to work with as well as a permanent record of the measurement. I have found that negative prints (black stars on a white background) are easiest to work with and therefore I use slide film, placing the slide in the enlarger and treating it as a normal negative.

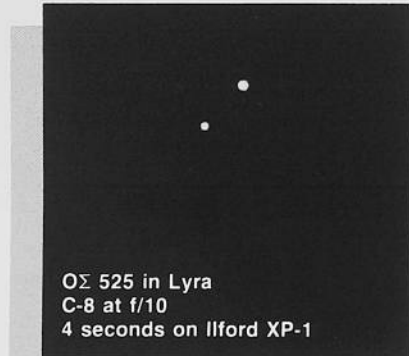
If you decide to make measurements off your prints a few precautions should be observed to make sure that your enlarger will not introduce distortions.

As in measuring with a microscope you will have to sandwich the film between two pieces of glass to ensure flatness. If your enlarger doesn't come with glass negative carrier, see if the manufacturer sells one — or make one yourself from two pieces of thin glass. Next check that your enlarger holds the negative parallel to the baseboard. If your enlarger cannot be adjusted for parallelism you can shim the printing easel.

The last component to consider is the enlarging lens itself. If the lens will not project a flat linear field then the measurements will be off. The best way to check this is to place a Ronchi screen (again, try the Edmund catalogue) in the negative carrier and make an exposure. Once the resulting print is dry a straight-edge laid along any of the lines will reveal any distortions. Remember that most enlarging lenses are at their best stopped down two to three stops from wide open. Find the f/stop that works best and stick to it, controlling print density by exposure time only.

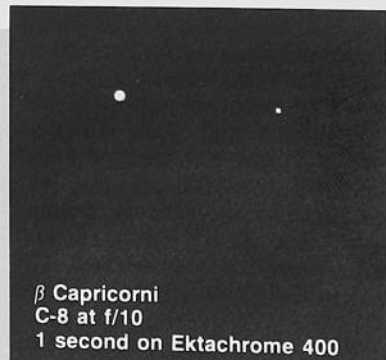
Satisfied that your enlarger is working well, proceed with printmaking. Your first exposure should be of the calibration frame (the pair with the known separation) — this sets the image scale for all subsequent exposures. Then go on to print the other frames you want to measure. Keep in mind that you must reprint your calibration frame every time you change the height of your enlarger. Keep the calibration frame and all prints made at that same scale together in a batch. Label each print of a given batch on the back in pencil before processing. Code the batches with an A, B, C, or whatever you like.

Once the prints are dry, carefully measure the distance from the estimated center of the primary star's image to the estimated center of the secondary. This is the separation distance. Next, run a line through the primary star image parallel to the east-



never smaller than a few arcseconds in size and often much larger.

In addition, the accuracy of photographic measurements obtainable with your backyard telescope can't compare with large astrometric refractors sporting focal lengths in excess of 8,000 mm. Nevertheless, amateur observations can be useful. There are many double stars in the sky and few professional observers observe them. Most pairs studied by the professionals have close separations because these yield to attack only with large instruments. Therefore, many of the wider pairs in the sky — ideally suited for small telescope work — are overlooked and have not been measured for many years. (If you



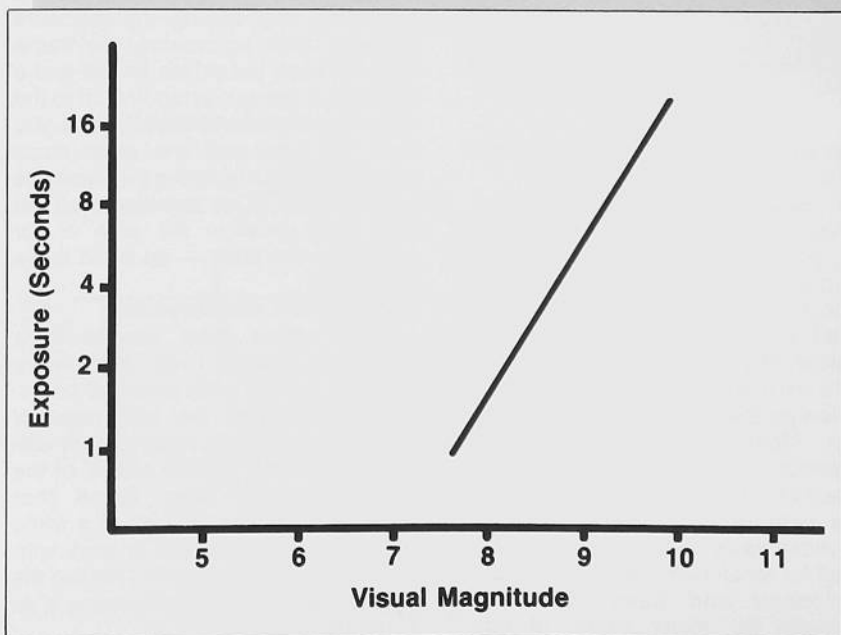
All photos by the author



west trail on the print. The west or preceding point of this line is marked 270° . The opposite or following end is marked 90° . Next bisect the primary with a line at right angles to the east-west axis. This line defines north-south.

Now carefully draw a line from the center of the primary image through the center of the secondary and extend it well beyond. The pair's position angle is now a matter of taking a protractor (use a circular one that shows half degrees) and measuring from the north line to the line between primary and secondary, counting toward the east. In cases where both stars leave trails whose start and end are on the frame, repeat the measurement using all the starting and ending points of the star trails. This allows three separate measurements on one frame.

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Double Stars

Exploring the Struve Catalog

by Glenn F. Chaple

My favorite double star catalog is the one produced by the German-Russian astronomer F.G.W. Struve over a century and a half ago. Earlier catalogs tend to be cluttered by wide uninteresting pairs, while later ones are often comprised of double stars beyond the resolving power of most amateur-owned scopes.

Struve compiled his catalog between the years 1824 and 1827. Using the magnificent 9½-inch Fraunhofer refractor — for many years the largest telescope in the world — at Dorpat, Russia (now Tartu, Estonia), he systematically examined the entire sky down to -15° declination. All stars brighter than magnitude 8.5 — 120,000 in all — were checked for duplicity. Struve ignored pairs separated by more than 32 seconds of arc — a decision that excluded showpieces like Albireo and ν Draconis but also culled less spectacular wide doubles. The final result was a catalog of 3,134 pairs that includes a great many of the finest double and multiple stars visible from northern latitudes.

Most of the Struve doubles are resolvable with modest size telescopes. Using a 3-inch f/10 reflector and magnifying powers between 60x and 120x, I've managed to "notch" over a third of them. I suspect that nearly all could be captured by a good 5 or 6-inch refractor.

To introduce you to the Struve catalog, I'll describe in detail the first 10 entries. How many of these can you notch?

$\Sigma 1$ And

Struve's first entry lies 2° west and

slightly north of σ Andromedae. I have yet to split this relatively fixed pair with my 3-inch reflector, but I am sure a good refractor of this aperture would do the job under steady seeing conditions.

$\Sigma 2$ Cep

Right away, we stumble upon one of the more difficult Struve pairs. This binary system, with a period of about 300 years, is slowly widening. By this century's end, the component stars will be 0.8" apart in position angle 12°. With a 13.1-inch f/4.5 Odyssey I reflector masked down to become a 5-inch f/12, I couldn't resolve $\Sigma 2$. I nevertheless spotted a faint companion, about 12th magnitude, some 100 arcseconds away (p.a. about 330°). Can you see this star?

$\Sigma 3$ And

This pretty pair lies just 20' north of 22 Andromedae, so it easily fits into the same field. Relatively fixed.

$\Sigma 4$ Psc

On the night I viewed this twin system with the stopped-down Odyssey, I needed 180x for a clean split. According to the Lick catalog, the designated primary has a spectral class of G5. Does either star (or both) look yellowish to you?

$\Sigma 5$ Psc

34 Piscium. This pair is quite difficult, owing to its closeness and the magnitude difference. I needed 300x and averted vision to glimpse the companion with the Odyssey and 5-inch mask.

$\Sigma 6$ Psc

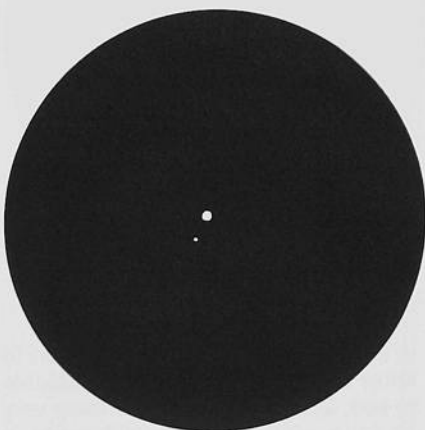
A relatively fixed double that, to me, is the least attractive of Struve's first 10.

$\Sigma 7$ Cas

A description of this close pair was sent to me by Canadian amateur Paul Brown, whose observations were made with an 8-inch Schmidt-Cassegrain. "Three stars aligned NW to SE in a ½° field and all of nearly the same magnitude confirm the correct field. $\Sigma 7$

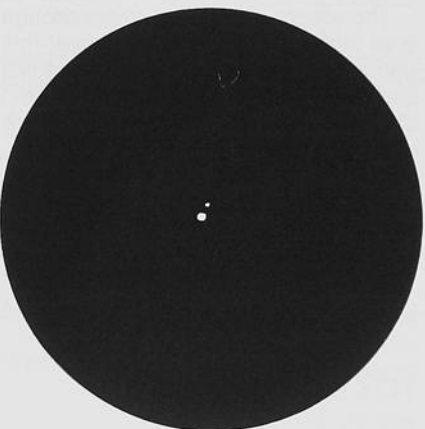
$\Sigma 2$

5-inch f/12 reflector
180x



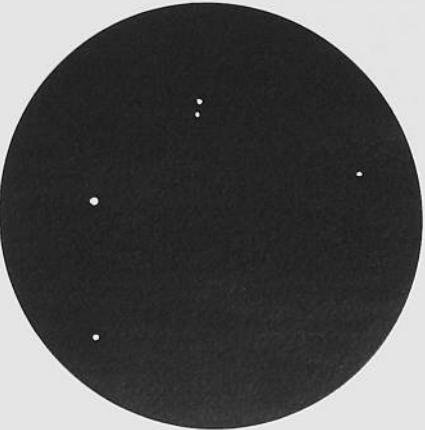
$\Sigma 5$

5-inch f/12 reflector
300x



$\Sigma 9$

3-inch f/10 reflector
60x



Star	R.A. (2000)	Dec.	Mag.	Sep.	P.A.	Year
$\Sigma 1$	0h 08.8m	+37° 13'	8.8, 10.3	9.7"	286°	1934
$\Sigma 2$	0h 09.3m	+79° 43'	6.6, 6.9	0.6"	25°	1982
$\Sigma 3$	0h 10.0m	+46° 23'	8.1, 9.1	5.0"	84°	1938
$\Sigma 4$	0h 09.8m	+ 8° 27'	9.3, 9.3	5.3"	274°	1955
$\Sigma 5$	0h 10.0m	+11° 08'	5.5, 9.4	7.7"	160°	1958
$\Sigma 6$	0h 10.3m	+ 4° 53'	9.7, 10.9	21.2"	193°	1922
$\Sigma 7$	0h 11.7m	+55° 57'	7.9, 9.4	1.3"	212°	1955
$\Sigma 8$	0h 11.6m	- 3° 05'	7.8, 9.4	7.8"	292°	1953
$\Sigma 9$	0h 13.8m	+49° 33'	9.4, 9.4	20.0"	166°	1923
$\Sigma 10$	0h 14.7m	+ 6° 50'	7.9, 8.6	17.6"	176°	1950

Sketches by Glenn F. Chaple, Jr.



Sketch by Glenn F. Chaple, Jr.

is the middle star. 160x just began to show separation that was comfortable to see, 200x made the separation very obvious, 400x made the difference in magnitude easy to see." The position angle of this double star has dropped a few degrees since Struve's time, so $\Sigma 7$ may be a long-period binary.

 $\Sigma 8$ Psc

The separation may be ample enough (see table), but the magnitudes of this pair are a bit on the faint side for small scope resolution. It was only with great difficulty that I split $\Sigma 8$ with my 3-inch reflector.

 $\Sigma 9$ Cas

I was introduced to this double star in elegant fashion — through the beautifully-crafted "eye" of a 6-inch Clark refractor. Not to be outdone, my little 3-inch reflector and a 60x eyepiece also captured $\Sigma 9$ quite nicely.

 $\Sigma 10$ Cas

This is another easy pair for small scopes. Like all the first 10 Struve pairs (except $\Sigma 2$ and $\Sigma 7$), it is relatively fixed, having shown virtually no orbital motion since its discovery.

* * *

DOUBLE TAKES: Special thanks to Paul Brown and Swanton, Maryland skywatcher Gus Johnson for their notes and sketches of $\Sigma 7$. Thanks also to Charles Worley of the U.S. Naval Observatory for the data on $\Sigma 2$.

For excellent listings of the more noteworthy Struve doubles, look through the pages of *Burnham's Celestial Handbook* or volume 2 of the *Sky Catalogue 2000.0*. The *Skalnate Pleso* (1950 coordinates) and Tirion's *Sky Atlas 2000.0* both plot the brighter Struve pairs, but a more detailed atlas like Becvar's old *Atlas Borealis* and *Eclipticalis* or the AAVSO *Variable Star Atlas* is a must for locating the fainter entries.

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That's true and it may lure some folks, but for me the main reason I love variables is because they are personal and they are fun.

Take **RU Pegasi**, for example. It's a dwarf nova which, like SS Cygni, periodically explodes when hydrogen gas is transferred from one component of the close double to the other, igniting in a flash of thermonuclear radiance. You never know exactly when the next outburst will take place!

Or look at a totally different type of variable called **Mira** in Cetus. This star, also known as Omicron (o) Ceti, changes its light output by six magnitudes in a period of about nine months. (That's a factor of about 250 times! Can you imagine if our Sun started doing this?) You don't need a big telescope to watch Mira, either, since at its (sometimes) third-magnitude maximum, it's easily visible to the naked eye. Even at Mira's minimum magnitude of 9.2, it isn't too hard to see with a small telescope. (See the chart in *Deep Sky 4*.)

Mira is the prototype of the largest class of variables, the long-period family, so its period and behavior are pretty well understood. But it's still fascinating to watch this star twice a month and follow its behavior. Maybe Mira will have an unusually faint maximum, or a sharper than normal rise from minimum, or a short period of little variation at all, or half a dozen other possible deviations from what the book says it should do. Don't be shy — go outside tonight and observe it. The star is easy to find — in the tail of Cetus — and easy to estimate. After you've spent a little time with Mira, you'll get a sort of proprietary feeling — as if this star is performing strictly for you. This way of looking at a variable is hardly scientific, but it sure makes observing more fun.

For our next stop, let's visit a couple of bright variables in Cepheus. These are stars which change visibly, not over months, but over days. The first is **Delta Cephei**, a bright giant star with a period of 5.366341 days (see chart in *Deep Sky 4*). It displays a slow drop from maximum to minimum followed by a more hurried return to top brightness. Delta Cep is a beginner's variable, an easily-found star whose two comparison stars are neighbors. Magnitude 3.6 Zeta Cephei closely approximates Delta Cep at maximum, and magnitude 4.2 Epsilon Cephei closely approximates Delta Cep at its minimum. This makes it easy to estimate Delta Cep, which usually falls somewhere in between.

Delta Cephei is the well-known prototype of the Cepheid class. These stars' patterns of behavior have unlocked some of the darkest secrets of the universe.

At the Harvard College Observatory early this century, Henrietta Swan Leavitt was examining the periods of a

Variable Stars

Take a Crack at a Cepheid

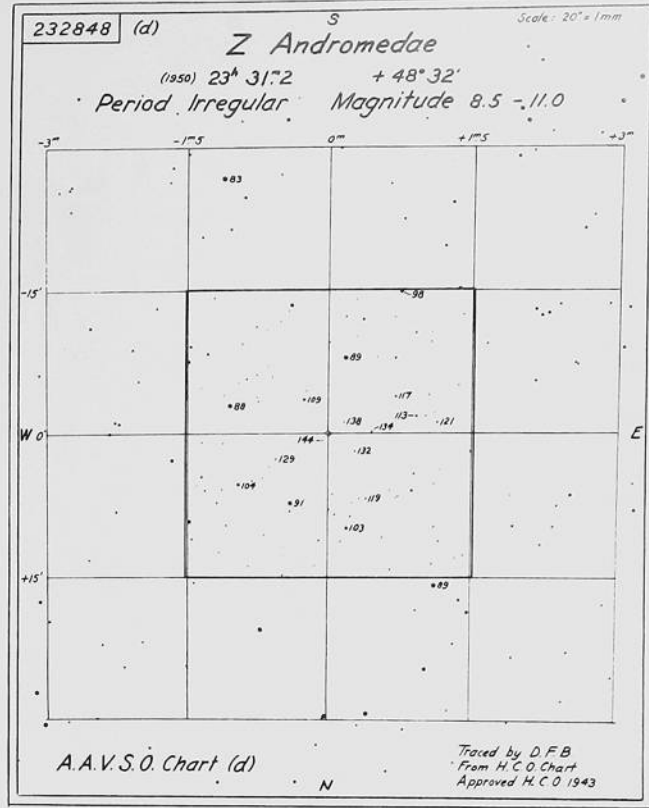
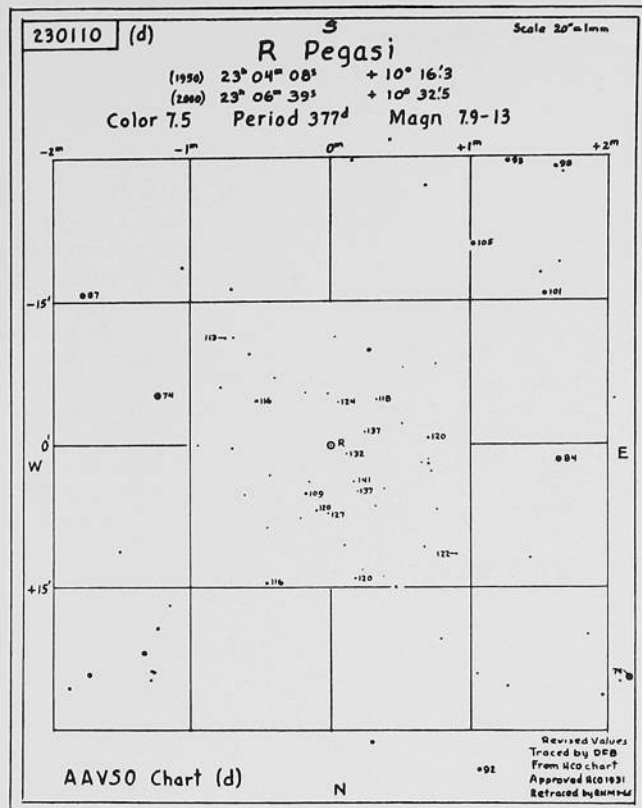
by David H. Levy

Fall is variable star time. The weather is usually great and the selection of variables is probably better than any other season of the year. In the west, we still have the good variables in the summer Milky Way, while toward the east the winter variables of Orion are rising and gaining prominence. Fall also marks the beginning of a new "fiscal" year for the American Association of Variable Star Observers (AAVSO).

The fiscal year starts with the AAVSO's annual meeting, where members find out who did what and how much and when for the past 12 months. For instance, one report is about a Wisconsin group that produced over 4,000 observations of eclipsing variables using telescopes set up around a field, each focused on a different star. Observers went from scope to scope, estimating variable after

variable. We also find out that some fellow in Arizona has been following Orion variables, and that our observations of the cataclysmics are needed more than ever since the professionals currently think they give off X-ray bursts. It's become important research now. We also learn about the latest literature on variables, we make new friends among the variable star observers, and we leave with fresh enthusiasm for observing these strange stars. And we find out something else — that there really are a lot of people who enjoy observing variables!

If you are as fanatical about variables as I, you've probably discovered this field isn't the most popular among many of the amateurs who attend astronomy club meetings. Observing the changing light from these distant suns lacks the luster of the Messier hunt, say, or glossy galaxy photos — or even the group thrill of a meteor watch. It's hard to get people wound up over variables! Some say the main attraction of variables is that they offer amateurs a chance to make a relevant contribution to science.



A long-period (Mira) variable, R Pegasi has an 8 magnitude range and a period of about a year. This chart covers it at its dimmest. Z Andromeda has no predictable pattern at all — who knows what you'll see when you observe it? Charts reproduced by special permission from AAVSO director Janet A. Mattei.

large number of Cepheid variables. She noticed how some of these stars had longer periods than others. Since they were all in the Magellanic Clouds, they all lay at about the same distance. Thus a star that *looked* brighter was brighter on average. Leavitt discovered that the fainter the star's brightness, the longer its period. Period and luminosity connected directly. She then calibrated the system by checking against a few local Cepheids whose distances had been determined by other means.

In doing so, she developed a very powerful tool: by observing the period of any given Cepheid, she could obtain its distance. No matter how faint a Cepheid appeared, any astronomer could deduce its brightness and therefore its distance as well.

The system has been refined considerably since then, but the principle still holds. Edwin Hubble and others have used it to determine the distance to a few Local Group galaxies. But we are limited to only Cepheids in nearby galaxies. When the Space Telescope is launched, it will discover Cepheids in galaxies farther away. With a little luck, it won't be long before our idea of the size of our corner of the universe is known much more confidently — thanks to Cepheids.

Surely stars so valuable to professional astronomers must make

good targets for amateur observers. They do, but there are problems. Cepheids' periods are short, ranging from less than a day with the RR Lyrae types to almost two months for other Cepheids. With (average) six-day periods and one-magnitude ranges, you can imagine how difficult observing some of these stars can be.

So exercise great caution in estimating Cepheids. Unless a professional astronomer has firm confidence in visual estimates, he's more likely to attach a photometer to his telescope and get the reliable data himself. Stars of small amplitude and short period really push the limits of eyeball estimating.

While visual observations of Cepheids must be made with the greatest care, this shouldn't prevent you from enjoying these stars — the need for precision should only add to the fun. Remember: as an amateur, your prime purpose is to *enjoy the stars*; if your work is also appreciated by a professional astronomer, that's a nice bonus.

Another bright star in Cepheus — less familiar, but equally as interesting — is the huge red giant star **Mu Cephei**. You can use the same two comparison stars as for Delta Cephei, even though Mu exceeds them on either side of its light curve. Mu Cep is an irregular variable

star. (A note for any double star observers who've strayed into this column — nearby is a field that contains two of the nicest multiple stars you'll ever see: $\Sigma 2816$ and $\Sigma 2819$.)

Some recommended variables for more advanced observers this season include:

230110 R Pegasi Magnitude range 7.1-13.8, period 378 days. An interesting Mira star with a period of just over a year. As with most Miras, estimate this one every two weeks.

232848 Z Andromedae 8.0-12.4. A totally irregular, symbiotic star that presents major outbursts up to four magnitudes in amplitude. While these outbursts are rare, smaller variations up to half a magnitude are more common.

021558 S Persei 7.9-11.1. A slowly varying irregular variable in the Double Cluster. I have mentioned it before and a number of readers have observed this interesting star.

032443 GK Persei A faint star, perhaps around 13th magnitude, that in 1901 exploded to zero magnitude. Old novae like GK Per are always worth watching from time to time; this one varies slightly from month to month on a totally irregular basis — perhaps, as Leslie Peltier once wrote, it's "a star still searching for the fountain of youth."

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Scanning the Literature

January — April 1985

by Brian Skiff

Studies of globular clusters both within and beyond the Milky Way continue apace. Some of these may be of interest to visual and photographic observers.

An especially thorough examination of the globulars in the Andromeda Galaxy has been published by D. Crampton, A. Cowley, D. Schade, and P. Chayer ("The M31 Globular Cluster System," *Astrophysical Journal* (*ApJ*) **288**:494, January 15). The authors took slitless spectra plates using a grating-prism-lens combination called a "grens" at the prime-focus of the 3.6-meter CFH telescope on Mauna Kea. The spectra facilitated distinguishing the clusters from other slightly fuzzy objects. HII regions, for example, were distinctive due to their characteristic emission-line spectra. After digital scanning, colors for each cluster were estimated by measuring the slope of the continuum brightness between the blue and red ends of the spectra. Although M31 contains about four times as many globulars as the Milky Way, the overall properties of its system are similar to ours. The final catalogue of 509 cluster candidates includes precise positions, magnitudes, colors, and apparent diameters.

Of more distant globular cluster systems, about all that can be told from ground-based observations is that they exist. Nevertheless they provide important tests of models of the cluster system around the Milky Way and formation of galaxies in general, thus are worthy of study. Another in a series of reports on this problem concerns two nearby galaxies away from the Virgo cluster ("Globular Clusters in Galaxies Beyond the Local Group. IV. The Elliptical Galaxies NGC 524 and NGC 1052," *ApJ* **291**:147, April 1). These two bright galaxies lie in Cetus and are members of small groups. The globular cluster systems of galaxies are visible as concentrations of faint, star-like images centered on a galaxy and extending for a radius of several arcminutes. The present study is based on star counts made on CFH prime-focus plates that reach fainter than magnitude 24.

NGC 524, the more luminous galaxy, has a greater population of objects — about 700 globulars were counted over the background of faint stars and distant galaxies spreading over a large area of

the sky. For NGC 1052 the counts are less certain, but clearly the population is smaller than for NGC 524. Because the distances to the galaxies are uncertain by a factor of two, the absolute magnitudes of the visible clusters are uncertain: the counts are more complete when the galaxies are relatively close rather than distant. Harris and Hanes estimate, however, that NGC 524 has at least 2000 (and possibly up to 10,000) globulars, while

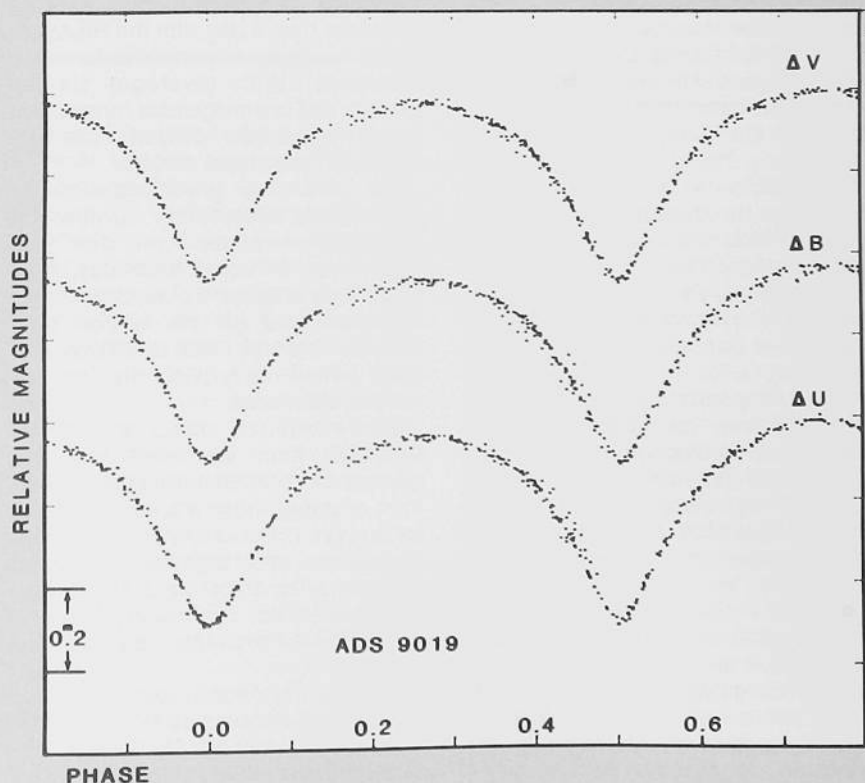
NGC 1052 has between 300 and 900.

Another of the faint, distant globular clusters belonging to the Milky Way has undergone its first basic examination in the hands of Gary S. DaCosta ("CO422-213 (Eridanus): A Second Intermediate Metal Abundance Globular Cluster in the Outer Galactic Halo," *ApJ* **291**:230, April 1). Although visible on the Palomar Sky Survey, this object was first noticed only 10 years ago on plates taken with the ESO 1-meter Schmidt in Chile. A color-magnitude diagram for the cluster was derived from CCD images taken with the CTIO 4-meter telescope. Analysis of the color-magnitude diagram confirms earlier suspicions that the cluster is a globular at a distance of 84 kiloparsecs from the galactic center — only four clusters are known to lie further from the center of the Galaxy. From previously published star counts, the newly determined distance implies a total diameter of approximately 80 parsecs. There is a well-defined clump of red stars on the horizontal branch, while the overall giant branch morphology suggests a metal abundance fairly high for outer-halo globulars which are expected to be metal-poor. Summing the photometry, DaCosta derives a total V magnitude for



Kitt Peak National Observatory

M87: Two normal novae become the faintest variable stars ever observed.



Richard L. Walker

Light curve for the variable ADS 9019: a hidden contact binary is uncovered.



M31 resolved into stars: globular clusters similar to the Milky Way's.

Palomar Observatory

the cluster of 14.8 or an absolute magnitude of only $M_v = -4.85$ which is typical of low-luminosity outer-halo globulars. A single supergiant star could easily outshine it!

The remarkable discovery of normal novae in M87 was announced by Chris Pritchet and Sidney van den Bergh of Canada's Dominion Astrophysical Observatory in August 1984 on IAU Circular 3974. Their full report appeared in the January 15 issue of the *Astrophysical Journal Letters* ("Observations of Two Novae in M87," *ApJ* **288**:L41). The authors used a CCD camera on the busy CFH telescope for several nights in February 1984. The hour-long exposures reached beyond B magnitude 25. Two normal novae were found peaking at magnitude 24 — probably the faintest variable stars ever observed. The absolute magnitudes of novae at maximum fall within a fairly narrow range of brightness and are correlated with the rate of decline following an outburst. Thus they are fair distance indicators if we assume extragalactic novae are similar to those in the Milky Way. The present fragmentary observations suggest a distance to M87 between 12 and 30 megaparsecs; not a narrow range, but within the range of earlier estimates by various methods. Continued observations, reportedly underway, should place tighter constraints on the distance to the Virgo cluster.

A list of early-type galaxies with large amounts or unusual distributions of dust has been compiled by Kate Ebner and Bruce Balick ("A Catalog of Dusty Elliptical Galaxies," *Astronomical Journal* (AJ) **90**:183, February). About

100 objects are listed, the brightest of which is NGC 5128. The selections were made from the literature and personal lists of many astronomers, and not from a systematic search of survey plates. Consequently, the authors note, the list is biased and incomplete. Small anomalies visible in nearby galaxies are invisible at great distance, so most of the selections are bright. Further, radio sources are probably over-represented since these often come under careful scrutiny. The catalog includes identifications, positions, magnitudes, references, and other information for each galaxy.

An interesting double star containing an eclipsing binary has been studied by Richard L. Walker and Carlson R. Chambliss ("A W UMa Variable in the Visual Binary System ADS 9019: A UBV Photoelectric Investigation," *AJ* **90**:346, February). The double star is a well-known close pair with a period of around 300 years (in 1981 its separation was 0.3" in p.a. 118°). One star of the pair was suspected to be variable because observers in the past had reported a wide range of "delta m's" — the magnitude difference of the two stars. The B component is the variable, which Walker confirmed visually in less than an hour's time. Photoelectric measures at the U.S. Naval Observatory in Flagstaff showed the light curve of an eclipsing binary of the W Ursa Majoris type. This class consists of stars of F and G spectral types that are in contact or nearly so, making them egg or teardrop-shaped. In this case, the plane of the orbit lies in our line of sight, causing the eclipses. The components of the eclipsing pair are essentially

identical stars since both minima are of equal depth, falling from $V = 7.06$ to 7.48 twice during the 9.8-hour cycle.

Incidentally, an exhaustive multicolor photometric study of W UMa itself (also a wide double star) by Albert P. Linnell was published in the March 1985 *ApJ Supplements* (57:611).

Having a great interest in open clusters, a paper by R. Fenkart and A. Schroder was the first thing I turned to in the January 1985 *Astronomy and Astrophysics Supplements* ("UBV Three-Color Photometric Parameters of Four Galactic Clusters Near Cassiopeia," 59:83). However, I was sorely disappointed. The four clusters examined are NGC 7510, NGC 7654 (M54), Basel 2 (better known in the literature as King 19), and Basel 3 (better known as Markarian 50). Photographic photometry was done on plates taken with the 65 cm. Asiago Schmidt — really too small an instrument (due to insufficient image scale) to measure crowded clusters such as these. Only the color-magnitude diagrams are given with the paper: no data, no star identifications, no chart. Further, there is no analysis of errors; to judge from the color-magnitude diagrams, the numbers would not be flattering. The authors claim the data, charts, and complete analysis will appear in a report series published by the University of Basel (Switzerland), by no means a widely-circulated product. Worst of all, each of these clusters has been studied before — and in two cases (M54 and Ma 50), more thoroughly and to higher precision. Next!

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Spiral Galaxy NGC 6744 in Pavo

Anglo-Australian Telescope Board photograph